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UNIVERSITY OF ILLINOIS

SCIENTIFIC AMERICAN SUPPLEMENT. No. 1751

Entered at the Post Office of New York, N. Y., as Second Class Matter.
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Published weekly by Munn & Co. at 361 Broadway, New York.
Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXVIII., No. 1751. NEW YORK, JULY 24, 1909. Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

ELECTRIC OVERHEAD RACK-RAIL TRANSPORTER FOR HANDLING MEAT.

An interesting type of transporter which possesses many interesting features has recently been completed at the Trafford Park Works of Messrs. Royce, Limited, the Manchester firm of engineers, for the purposes of handling meat at Buenos Aires, South America. The installation comprises a girder track of an approximate aggregate length of 600 feet, along which run two electrically-driven transporters of one-ton capacity apiece. The track is in two portions, and includes both curves and inclines. The transporters have a hoisting speed of 20 feet per minute, while their traveling speed is 200 feet per minute, the height of the lift being 22½ feet. The overhead track has gradients of 12 per cent, and it is built up of a girder 12 inches in depth so jointed as to make a continuous runway throughout its entire length. Owing to the steepness of the grades, it was found impossible to rely upon adhesion only for the transporters, so that it became essential to introduce a rack with which the traveling wheels of the transporters could engage, this toothed track being attached to the underside of the bottom flange of the girder. The rack extends from one end of the runway to the other, and a driving pinion on the transporter is in constant engagement with this rack, thereby avoiding any trouble incidental to meshing with the teeth, such as would result if the rack sections were only provided on the inclines.

For the rack stretches on the inclines cast steel is utilized, while on the level sections cast iron is adopted. The main conductors for the supply of the current to the transporters are attached to one side of the track, being supported on cast-iron brackets fitted with insulated bolts, comprising a small section of tee iron, which was found to be considerably more suitable for bending to the curves and gradients than copper wire, as well as offering the additional advantage of simple and easy erection, and at the same time being quite good enough for current-conducting purposes.

The electrical equipment is throughout of the Royce type and design. The motors are totally inclosed, series wound, crane-rated to work with direct current at 220 volts, with controller of the ordinary street surface railroad type, reversible, and each fitted with a separate external resistance. Regenerative electrical control is supplied to the traveling motions, so that the speed of travel down the inclines may be regulated and retained within perfect control.

Moreover, an automatic electrical brake is supplied on the traveling motor, so that in the event of the current supply being suddenly cut off or failing while one of the transporters is on an incline, the brake is instantly brought into action, holding the transporter stationary and thereby preventing its running away. This brake also permits of the transporter being stopped and held on a grade while a load is being lifted.

The framework comprises mild-steel channels with steel channel cross bearers and steel sling plates at the ends, the whole being riveted up. The hoisting motor and gearing are mounted on the framework carried on two cast-steel bogies, one at each end, each bogie being fitted with four cast-steel traveling wheels in order to secure a proper distribution of the load and to insure easy traveling around curves. A universal joint secures the coupling between the bogies and the frame, this system eliminating all side stresses due to the swinging tendency of the load and framework when negotiating curves from the suspension pins, as well as the racking strains due to backward and forward drive. The suspended weight of the transporter is carried on ball bearings fitted to the suspension pins.

Each bogie is equipped with safety catches, so that in the event of a failure of a traveling wheel or axle they would drop on the flange of the runway, and prevent the transporter from falling to the ground. Steel spur wheels and pinions, machine cut from turned blanks, provide the means of securing reduction in speed from the motor for both traveling and hoisting motions. The hoisting barrel is spirally grooved to suit the rope, there being automatic rope guides to guide the ropes into the correct grooves as well as preventing them from being pulled out in the event of the load being lifted in a sideways position.

The traveling wheels are of cast steel. The hoisting motion is provided with an automatic electrical solenoid brake, fitted with a device which enables it to be released by hand from the cage. There is also installed an over-winding device, which though allowing the hook being taken right up to the barrel, thereby insuring the maximum of lift, prevents any injury being inflicted upon the rope gearing or motor. As a matter of fact, by means of this special safeguard the hook can be held in its highest position and the motor kept running.

TWO ROYCE TRANSPORTERS WITH PART OF INCLINED AND CURVED TRACK ERECTED IN SHOP FOR TESTING BEFORE SHIPMENT TO BUENOS AIRES.

ELECTRIC OVERHEAD RACK-RAIL TRANSPORTER FOR HANDLING MEAT.

THE SMALL MOTOR BOAT.*

ITS CARE AND OPERATION.

BY HAROLD WHITING SLAUSON.

THE length of life of a motor boat and engine is so dependent upon proper care that it will pay every owner of such a craft to understand thoroughly the vital points to be remembered and to see to it personally that the boat and power plant are kept in the top-notch of condition. If he does this, motor boating will become a pleasure, and no serious trouble should be anticipated from unexpected and inconvenient breakdowns.

It would seem almost unnecessary to state that every present or prospective motor boat owner should first become familiar with the mechanism of his motor boat before he starts to operate his boat—that he should know the function of all parts of the ignition system, the carbureter, and the reverse gear; but from the number of accidents that have been caused by ignorance of the why and wherefore of these parts, it appears that such cautions are important. There is probably no better way of becoming thoroughly familiar with the details of construction of a marine motor than to personally perform or inspect its complete overhauling at the beginning of each season.

If possible, the boat should be hauled out of water at the end of each season in order to protect the hull from the ice and snow and to afford a convenient means for painting the bottom during the succeeding spring. If the boat and motor are small, it is sometimes advisable, before hauling the boat out of water, to remove the heavy parts of the motor, which would be taken apart subsequently for cleaning, and thus avoid the strain which probably would be caused by the extra dead weight of these parts. If the motor has a solid cylinder head, the entire cylinder, piston and connecting rod, and flywheels and crank shaft should be removed; and as these parts constitute almost the entire weight of the engine, the work of drawing the boat out of the water should be lessened considerably. Before these parts of the motor are stored for the winter, all exposed iron or steel surfaces, such as the crank shaft piston, and inside of the cylinder, should be covered with a heavy coating of grease, to keep off the moisture and prevent rust. All smaller parts, such as nuts, bolts, and screws, should be placed in a box by themselves and kept with the larger pieces of the engine.

The smaller and medium-sized boats should be supported in at least three places, when they are hauled out for the winter, so that the weight will be distributed evenly between the bow, stern, and amidships. Precautions should be taken also to prop the hull on an even keel, and while "bilge blocks" are often used for this purpose, this is hardly as satisfactory a method as that in which wooden forms, shaped to fit the curvature of the hull, are placed against the boat amidships. If there is no building in which the boat may be stored for the winter, a stout canvas covering, cut to fit the cockpit and decks of the craft, should be made to protect these parts from the snow and rain. If the boat is of the open type, two supports, on which is fastened a ridge pole, should be placed at either end of the cockpit to form a frame which will give a sufficient slant to the covering to enable it to shed water.

The precautions which apply to the calking and painting of the hull both above and below the water line, the varnishing of the decks, and the drying out of the interior are the same for a motor boat hull as for a sailing craft, and cannot be described in detail here. Suffice it to say that the proper care of the hull—both inside and out—not only adds greatly to the appearance of the boat, but will also increase its length of life by several years.

Of course the vital part of a motor boat is the motor, and too much time cannot be spent each year on the thorough cleaning, readjustment, and replacement of lost or broken parts of this small power plant. Inasmuch as the power developed by a gasoline motor depends to a large extent on its compression, and good compression, in turn, is impossible without perfect fitting piston rings, it will be realized that these small circular pieces of cast iron require considerable attention. It is quite possible that one or more of these may have become "stuck" in its grooves, due to an insufficient supply of oil or excessive carbonization in the cylinder, and if such is the case, great care must be exercised in loosening these rings without cracking. They should be worked and loosened gradually with the aid of thorough applications of kerosene and oil, and even the most recalcitrant one may be removed if sufficient care and patience are used.

After this the rings should be scraped and cleaned thoroughly and all of the carbon deposit removed from the grooves. Each ring should then be replaced in the same groove from which it was removed, as otherwise some slight difference in thickness may be found which would make one too tight and another too loose a fit. Even though all the rings are found to be intact, it is quite possible that some may be so badly worn that they would allow the charge in the cylinder head to escape past them, and such rings as are found in this condition should be replaced by entirely new ones. The fact that a certain ring has been "leaking gas" will be evidenced by the blackened appearance of the piston and ring where the burning charge has scorched the metal on its way to the lower part of the cylinder. It is not advisable for an amateur to endeavor to fit new rings in the piston, as this is a very particular and delicate operation and requires the services of an expert gas engine repair man.

While it is possible for an engine to run with leaky piston rings, there are other parts which require careful attention and adjustment, before even a single "put" may be had out of the motor. In fitting up for the season, absolutely fresh batteries must be used, for even though the cells gave a good spark at the end of the previous season, their long rest will have so caused them to deteriorate that they will be unfit for ignition purposes. The timer and its parts should be cleaned thoroughly with kerosene, and fresh oil applied to the moving parts. In case it is found necessary to remove any part of the timer or commutator, care should be taken to replace these parts in the proper manner, so that, with the timer handle set in the center, the spark will occur at the top of the piston's up-stroke.

When the fresh batteries are supplied, the timer cleaned, and the proper connections made, the quality of the spark at the plug should be tested. In case this does not appear to be a strong, blue-violet spark, the trouble may lie either in the spark plug or in the platinum contact points of the coil. In the former case, all soot and carbon should be removed, fine emery cloth used to polish the sparking surface, and the points of the plug so set that the spark jumps a gap of about one thirty-second of an inch. If the trouble is found to lie in the coil, the thumb screw and vibrator should be removed, and the platinum contact points polished with emery cloth, until all signs of a pitted or corroded surface disappear. It is very probable that these adjustments on the plug and coil will have to be made several times a year, and in case trouble is found with the ignition system when it is certain that the batteries are sufficiently strong, the whole operation of cleaning and testing may have to be gone through with as at the beginning of the season. In other words, because the ignition system has been put in good shape early in the season, it is no guaranty that it will remain in this condition throughout the summer. Piston rings and bearings are parts of the motor that may reasonably be expected to stay in shape for a year, but the future behavior of the ignition is often a source of doubt.

It is to be assumed that when the boat was put up for the winter, all the gasoline was drained from the tank and carburetor. Before filling the fuel tank at the beginning of the season, the fine wire strainer, generally located in the supply pipe near the carburetor, should be removed and cleaned of all the dirt and foreign matter which may have collected from the gasoline. The needle and air-intake valves of the carburetor should not need grinding or cleaning, as there is very little wear on these parts and the gasoline acts as a good dirt remover. Possibly a slight adjustment may need to be made in the height of the cork float which operates the gasoline valve, but any change in this should be made with very great care, as a slight turn of the regulating nut will make a considerable difference in the quality of the mixture and the action of the carburetor. Care should be taken to see that there are no particles of sediment or loosened solder in the gasoline tank, which could find their way into the supply pipe and clog the flow of fuel to the carburetor.

In a small engine, it is not probable that the bearings would need any attention, aside from cleaning, in several years. The crankshaft and the connecting rod bearings should be examined, however, to see that they are not unduly worn and to make certain that they have been getting their share of oil. None of the bearings should be very tight, as this would cause the babbitts to heat and possibly burn out—an occurrence the results of which would be more serious than those caused by too loose a bearing.

About the only other part of a marine motor which will require attention at the beginning of the season is the lubricating system. It is of the utmost importance that all pipes running from the oil cups to the piston, crank case, and bearings should be absolutely clean, to allow a free flow of lubricant to these parts. The best way to clean these is to fill all oil cups with kerosene and allow it to run through the connecting pipes, until the old or gummed oil is entirely dissolved. The crank case should be cleaned out and supplied with fresh oil. If the lubrication is forced by the pressure-feed system, the pipe running from the engine cylinder to the oil tank should also be cleaned thoroughly in the same way.

Before the boat is put in the water, the flywheel, shaft, and propeller should be turned to make certain that the boat has not warped or sprung during the winter and thrown these parts out of line. If it is found that the propeller shaft does not line up properly with the crank shaft of the engine after the boat is placed in the water, the angle or slant of the motor should be changed until the correct alignment is secured. This may be accomplished by loosening the bed bolts of the motor and raising the front or rear part of its base, as the case may be, and holding it in the proper position by means of thin wedges of tin. After the proper alignment has been obtained, the motor should be bolted securely to its bed again.

When a man has once prepared his boat and motor for the season, he will have but little trouble in maintaining both in good condition. The ignition system, the fuel supply, and the lubricating materials are about the only parts which should require any further outlay of time or money, and a few minutes each day spent in cleaning, testing, and replenishing will not be wasted.

Every man who operates a motor boat should own a pocket ammeter, or battery tester, with which to keep himself informed of the condition of his source of ignition current. Dry batteries, when new, should show from twenty to thirty amperes on this instrument, and should be available for ignition service until the current output has dropped to six or eight amperes. Two sets of six cells each should be used alternately, so that one set may be recuperating while the other is furnishing current. The length of life of a set of batteries will depend upon the amount of running which the motor is called upon to do, but one hundred hours of intermittent running for two sets of six cells each may be taken as a fair average performance.

The spark plug should be cleaned and tested frequently, and several extra ones should always be kept on board to be used in case of necessity. The timer should be kept absolutely free from dirt and grease, but, paradoxical as it may seem, a goodly supply of oil on the brushes or contact points will help, rather than interfere with, its operation. The liability of short-circuits in the ignition system will be lessened greatly, if care is taken to protect all wires from grease, gasoline, oil, spray, or rain, and if the batteries and coil are kept in a dry place. The copper terminals, connecting the high tension conductor with the coil and spark plug, should be soldered securely to the wire, and the battery and all other connections should be so tight that it will be impossible for them to jar loose. The contact points of the coil should be kept bright and smooth, and should be so adjusted that excessive sparking does not occur at this place. It is the heat formed by these sparks, or electric arcs which, in a large measure, is responsible for the corroding and pitting of the platinum contact points.

The warning to always ascertain the amount of fuel on hand before starting out for the day would seem almost unnecessary, and yet the number of motor boats which will be found stalled on account of a dry gasoline tank attests to the fact that this is a precaution which is not always heeded. Almost as necessary as gasoline is a sufficient supply of lubricant, for whenever the motor is running, a constant stream of cylinder oil is required. If this supply is stopped or diminished beyond a certain point, the motor will become excessively hot, the piston will expand, and the whole machine finally will cease to run. The only way to start the motor again, after an accident of this kind, is to allow it to cool, and then, with the aid of copious quantities of kerosene and cylinder oil, to "limber it up," till the flywheel turns as easily as it did before. The piston rings and cylinder walls must necessarily have suffered some, however, due to the excessive friction of the unlubricated parts. It is necessary for the operator to cast his eye occasionally on the sight-feeds of the oil cups to see that each is delivering its proper

* Gas Review.

amount of oil. The relief cocks on the cylinders also should be opened at frequent intervals to make certain that the engine is discharging a slightly bluish vapor. This bluish vapor is generally an indication of a sufficient supply of oil for the pistons.

If a well-made motor, properly installed in a staunch hull, is operated by a man well versed in the attention required by his engine and boat, power boating should become a pleasure for him and those of his friends fortunate enough to be his companions on a trip or cruise. Marine motors are, after all, simple in construction, and, after the mastery of a few details, a man, having only an average knowledge of mechanics and machinery, should be able to operate one under all conditions with scarcely any trouble whatsoever.

A PROFILE TRACER.

DEVICE FOR REGISTERING THE UNDULATIONS OF THE GROUND.

BY THE PARIS CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

An automatic device for securing the profile of the ground such as is needed for railroad work and in like cases, has been recently invented in France. It consists of a wheel of rather large diameter which is drawn along the ground by the operator. The wheel is connected by a shaft to a box which contains the registering device, and thus as the wheel and its shaft are raised or lowered according to the profile of the ground, the corresponding indications are registered upon a band of paper, together with the distances which are covered. Such a device allows of making surveys of level with only one operator, and at the same time it is quite automatic. It is of great service in forests and other places where the work of surveying with ordinary instruments is often difficult to carry out. It also allows of working at night, which is a great advantage in tropical countries.

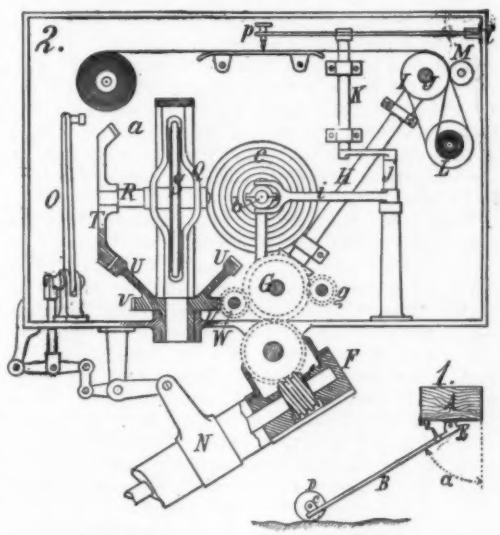
The registering apparatus proper consists of a stout mechanism which is contained in a box *A*, Fig. 1, suspended at the side of the operator. A water level is used to keep the apparatus nearly horizontal. The box is connected with the ground by means of a transmission shaft which runs through a tubular casing *B* and is operated at the lower end by a worm gear placed in the case *c* and connected with the main wheel *D* which rolls upon the ground. A similar set of gearing is placed in the box *E* for operating the mechanism. In this way the apparatus is made to register the distance covered by the operator. On the other hand, the variations in the angle *a* which the axis of the shaft makes with the vertical, allow of recording the depressions and elevations of the soil. The varying inclination of the shaft is made to operate a second mechanism which carries out the registering.

In order to record the distances which the apparatus covers, the following device is used (see Fig. 2). The upper end of the shaft *F* leading to the ground drives a worm-gearing and the motion is transmitted through a pair of gears to a second shaft *G* placed inside the box. This shaft operates the inclined shaft *H* by means of bevel gearing. At the upper end the shaft *H* by means of bevel gears drives a rubber roller *I* which by friction feeds the paper. The paper starts from the fixed roll and passes across a metal table *K* where the registering is done. It then passes over the rubber roller and is wound upon the lower roll *L*. This latter is driven from the shaft by means of a belt, as will be observed. The paper is pressed against the rubber roller by a milled roller placed at *M* and which is adjustable. Thus the paper will travel along at a speed which is proportional to the speed of the operator.

In order to register the profile of the ground on the path which is followed by the operator, the following mechanism is employed. Referring to Figs. 2 and 3, the tubular casing *B* carries a collar *N* which connects it with the mechanism in the inside of the box and allows the registering to be made according to the angle which is taken by the bar. The collar is connected by a set of levers and links to an upright arm *O* in such manner that the movement of the casing *B* gives a corresponding movement to the upper end of the arm *O*. To the end of the lever (see plan view Fig. 3) is connected a spring blade *P* which joins the lever to a system *a*. The latter is made to rotate about a pivot according to the movement of the lever *O*. The revolving system *a* is composed of a set of gears which in Fig. 2 are shown disconnected from the end of the lever. On the shaft *R* and within the yoke support *Q* is mounted the vertical friction wheel *S*. At the outer end of the same shaft is placed the bevel gear *T* which meshes with the gear *U*. The latter is integral with the horizontal gear *V* which is operated by the shaft *G* through the intermediate gearing *W*.

According to the angle which is taken by the main bar, the system *a* and the gear *S* can rotate about its axis, as we have seen. By this means, the gear *S* is engaged with any one of the series of friction gears that are assembled in the form of a cone *c* on a horizontal shaft *b*. The cone is splined to the shaft so that it can slide axially upon it. One end of the cone shaft carries a screw thread which works in a nut *d*. The latter forms the hub of a gear wheel *d'* turning in a fixed bearing and in mesh with a gear *e* mounted on a shaft *f*. The latter is worked from the gear wheel *G* by means of the pinion *g*.

Under these conditions it is seen that the cone shaft *b* is acted upon by the cone gears, which will be displaced longitudinally in one sense by its engagement with the nut *d*, while the pinion *e* by revolving nut *d* will tend to shift the shaft in the opposite sense. In other words, the shaft is displaced by the differential motion of gears *c* and *e*. This action of the nut *d* keeps up a constant value for a constant speed of the operator. Given the same speed of the operator, the action of the wheels will vary according to the angular position of the wheel *S*, that is, according to the depressions or elevations of the ground. The differential axial motion of the shaft serves to operate the pencil *p*. The shaft has a collar *h* mounted upon it, which is connected to the lever *i*, fixed to the shaft *j*. The latter is connected by a lever to a second shaft *K* lying near the top of the box. This shaft *K* engages



DETAILS OF THE MECHANISM USED IN THE PROFILE REGISTERING MACHINE.

a lever arm which is pivoted to the box at *l* and carries the pencil *p* at the other end, so that the rotation of the shaft *K* gives a movement of the pencil upon the paper. The amplitude of the swing of the pencil can be regulated by an appropriate device. The extremity of the arm carrying the pencil can be articulated so as to give an integrating action and thus secure the profile in a vertical projection.

As the apparatus is quite automatic the operator is free to take notes on different features of the country which are of interest. The upper side of the box is covered with glass which enables him to observe the mile-point indicated on the paper band so that he may note what special features occur at such points, such as the nature of the soil, water courses, woods, etc.

Copper-plating Sheet Zinc.—The sheet zinc, by washing in soda, is freed from dirt and grease and by means of a weak acid bath cleansed of any accumulation of zinc oxide. Then in 24 parts of water, 1 part of carbonate of copper (refined verdigris), as well as 12 parts of tartaric acid are dissolved, heated to boiling, and 3 to 4 parts of precipitated chalk added to this mixture. The washed chalk is decomposed and sinks to the bottom as tartrate of lime. The dark blue fluid is poured off and filtered and can be used as a bath for the sheet zinc, or also for the production of a copper-plating paste. The first named method of use is best because the fluid penetrates even into the angles and little corners of the zinc object and is uniformly distributed. If we wish to copper-plate stationary zinc articles they must be coated, after cleansing, with a mixture of the copper solution and chalk and after drying brushed off.

DAZZLING HEADLIGHTS.

Some striking experiments on the effect of over-brilliant light on color perception were recently reported from railroad shops at St. Paul. A bill requiring the use of large electric headlights on all locomotives was pending in the Minnesota legislature, and these experiments were directed toward establishing the effect of such lights on the train hands who had to face them. To a certain extent the conditions of the experiment were *ex parte*, inasmuch as the engineers on whom the headlight was being tested were compelled to line up squarely in front of it for some time instead of getting it as they naturally would on the road in occasional flashes. After dazzling the eyes of the engineers quite thoroughly, they were tried for their perception of colored signal lights, and it was at once apparent that exposure to the rays of the searchlight had in so far blinded them for signal lights that they could not be depended upon to recognize them. Four colors of lights were used in the test—red, green, yellow and white—and no one of the group of engineers tested was able after the exposure to the headlight to state correctly the 24 combinations of light which were shown him. This part of the test may be open to criticism because the inclusion of yellow and white made failure to determine between the two almost absolutely certain. It would have been indeed very remarkable had they been able to discriminate between the yellow and white lights after exposure even to the ordinary form of headlight used on locomotives. That they were unable to distinguish between the red and green lights is, however, a fact of serious significance, since these lights are reasonably easy to distinguish in the presence of any intrusive lights likely to be found at the present time along the railroad. It is undoubtedly true that very long exposure to the rays of an electric searchlight would be more than likely to produce serious temporary impairment of vision. A sufficiently bright light projected upon the retina is likely to produce permanent or long-enduring injury, even to almost total blindness in the area affected. Oculists note a few cases of this kind whenever a solar eclipse happens, owing to the careless exposure of the eye to full sunlight, possibly through field glasses at that. The use of very brilliant searchlights on street cars has been found to be generally objectionable merely on account of its temporary dazzling effect, and this result must be enormously increased with the powerful searchlights in occasional use on locomotives. Legislatures would do well not to dabble with these technical matters without expert advice.—Electrical World.

The Austrian State Railway Department has recently put in service a type of compound locomotive which has two cylinders, using a superheater of the Schmidt pattern which is placed in the smoke tubes. The locomotive has a bogie and two driving axles. The grate surface is 32 square feet, and the total heating surface, including the large and small tubes, 1,284 square feet, added to a superheating surface of 299 square feet. The cylinder diameters are 21 and 30 inches, respectively, with a 27-inch stroke. Walschaert valve distribution is used here. The weight of the locomotive empty is 57 tons. Nickel steel is employed for the driving axles, and these latter are hollow, having a 1.2 inch hole bored through them. On the tests which were made with the new locomotives they took 275 tons upon a 10 per cent gradient at 30 miles an hour, and their performance was much superior to what was given by similar locomotives, but without superheaters. The total weight of the locomotives when equipped for service is 62 tons.

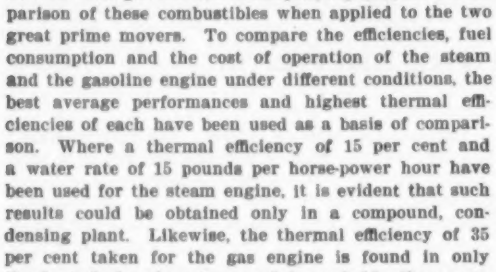
STEAM VERSUS GAS ENGINES.*

A GRAPHIC COMPARISON OF TWO POWER PRODUCERS.

OWING to the great variety of results obtained from tests of coal and gasoline as fuel for the steam engine and internal combustion engine, it is rather difficult to determine on a set of readings which may be taken as fair averages for the accompanying graphical comparison of these combustibles when applied to the two great prime movers. To compare the efficiencies, fuel consumption and the cost of operation of the steam and the gasoline engine under different conditions, the best average performances and highest thermal efficiencies of each have been used as a basis of comparison. Where a thermal efficiency of 15 per cent and a water rate of 15 pounds per horse-power hour have been used for the steam engine, it is evident that such results could be obtained only in a compound, condensing plant. Likewise, the thermal efficiency of 35 per cent taken for the gas engine is found in only the best designed motors, and is probably the exception rather than the rule in average internal combustion engine practice. The costs of the fuel used in the comparison ($4 per ton for anthracite coal and 15 cents per gallon for gasoline) will vary according to the locality in which each is purchased, but these figures are probably fair averages.

The relative weights of the two power plants, including engine, boiler, fuel and water tanks for the steam plant, and engine, gasoline tank and cooling apparatus for the gas motor, would form an interesting comparison. In the case of the gas engine, the minimum weight at which it is safe to construct a motor of a given power is definitely determined, for a gas engine is capable of but a very slight percentage of overload. The fact that the maximum explosive pressure will vary with different forms of mixture, and that all of this force is applied at one instant, determines a certain weight of engine per horse-power below which it is unsafe to design a gasoline motor. The steam engine, however, is capable of supplying for a time an overload greater than 100 per cent, and as this can be accomplished by slightly increasing the boiler pressure and lengthening the cut-off, the increased power developed in the cylinder is distributed over a greater length of stroke and consequently such an excessive strain is not communicated to the cylinder head and connecting rod. This reduction of the maximum pressure in favor of the steam engine, together with the absence of the necessity for water jackets, will probably bring its weight below that of the gas motor, but the total weight of the entire steam plant will depend on the type of boiler used. The average weight of a locomotive boiler is somewhat over 3 pounds per horse-power, but the introduction of the flash type of high pressure steam generator has enabled this figure to be considerably reduced so that special steam plants may be designed which will compare favorably with the gas plant as far as total weight is concerned. In view of the above, a graphical comparison of the relative weights of a steam and gasoline plant would not be a criterion of general practice, and could only represent a specific case.

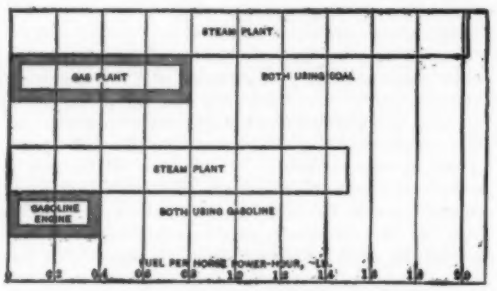
In showing the relative weights of the fuel and water required per horse-power hour for the steam and gas engines, it must be remembered that the



WEIGHTS OF FUEL (INCLUDING WATER) REQUIRED PER HORSE-POWER HOUR.

water consumption of an internal combustion motor may be set at a more or less arbitrary figure—depending on the amount of radiating surface provided in the cooling apparatus—and that in some motors no water whatever is used. The amount given in the diagram (10 gallons for 40 horse-power) is probably more than is used in any motor car, and would in all likelihood be an ample amount for cooling a stationary engine provided a sufficient radiating surface was supplied. It is also to be borne in mind that the same cooling water for a gas engine may be used over and over again, so that the amount of water required has but little to do with the length of time the engine is run. It is quite different with the steam engine where the water rate is a certain amount per hour and is directly dependent on the length of time that the power is delivered. Consequently for a day's run the comparative amount of fuel and water required for the two plants would be entirely different from that shown in the diagram—which applies only to an hour's run.

The two diagrams, one showing the comparative coal consumption for each engine and the other treating of gasoline in the same manner, may also be read as the comparative cost for fuel for the two plants,



RELATIVE FUEL CONSUMPTION.

since cost is directly proportional to consumption.

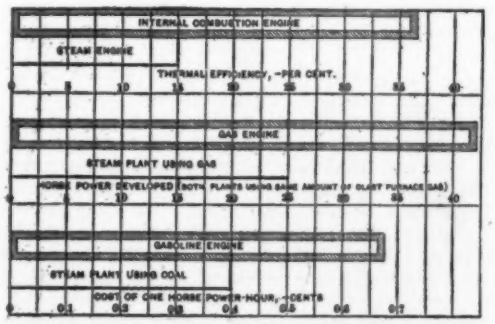
Probably one of the largest fields for the internal combustion motor is in plants where blast furnace gas is available. One of the diagrams will show the comparative power obtained from the same amount of this gas when used as a fuel for a boiler, and when applied to a gas engine, and the increase in power in favor of the latter is indicative of the economical use to which the combustion motor may be put. The cleaning of blast furnace gas required before passing it to a gas engine is a small item in comparison to the increase of power obtainable as compared with a steam plant.

From these diagrams it will be observed that the gas engine stands first in economy and efficiency in every case with the single exception of the cost of fuel when the steam engine uses coal and the combustion motor employs gasoline. In automobile practice, where the flash type of steam generator is employed, the design of the power plant has been brought to such a fine point that it is probable that the steam engine will deliver the same amount of power, gallon for gallon of gasoline, as will be developed by the gas motor, but this is a case where the steam engine is found at its best, and in stationary practice such a degree of economy in fuel utilization is seldom attained.

THE CONDUCTION OF ELECTRICITY.

IT is generally recognized that electricity is carried, in the case of fused or dissolved salts, by ions, and in metals and in kathode-rays by electrons; the method of conduction in non-metallic elements, in solid compounds, and in many liquids and gases has been regarded as uncertain. The following criteria are suggested by J. Koenigsberger in Elektro. Chem. Zeit: (1) *Transport of matter and separation of electrolytic products.* The passage of 3,600 coulombs through PbS, Fe_2O_3, Fe_3O_4, FeS, FeS_2, BaO, $KAlSi_3O_8$ never gives so much as 5 milligrammes of electrolytic product, while crystalline $BaSO_4$ soon produces a roughening of the electrodes, and a sulphate reaction can be detected by suitable methods. If in the first series of compounds electrolysis is to be assumed, a reverse polarization current must be postulated 10,000 times stronger than in water or in fused salts. No evidence of this is to be found in crystals of barium sulphate, and the assumption is very improbable. It was also possible that the conduction, though electronic or metallic in character, might be due to particles of free metal present as impurity in the oxide or sulphide. This assumption is rendered improbable by the fact that perfectly clear crystals of quartz show some degree of metallic conduction, and that in the case of lead sulphide it would be necessary to assume the presence, in all samples, of a constant quantity of free lead amounting to no less than 2 per cent. As a matter of fact, suspended metal is not capable of producing metallic conduction, even when present up to 25 per cent of Na or K in solid NaOH or KOH, or Pb as a cloud in solid $PbCl_2$; iron powder suspended in paraffin does not cause conduction, and metal suspended in fused salts does not disturb Faraday's law. The conclusion is therefore drawn that the compounds themselves show genuine metallic conduction. (2) *Polarization.*—This can readily be detected in barium sulphate at low temperatures when the resistance is a million ohms, and is but little affected when the resistance is reduced in the ratio 1 : 10,000 by raising the temperature 800 deg. But no polarization can be detected in pure adular, $KAlSi_3O_8$, up to 1,070 deg., although 0.0001 volt could be detected; great care is needed, however, to avoid thermo-electric effects. (3) As a rule substances which dissolve in water to form electrolytic solutions show electrolytic conduction in the solid state, while those which are insoluble or only form colloidal solutions show metallic conduction. (4) Homogeneous metallic conductors show a minimum resistance at some temperature, high or low, while homogeneous electrolytes show a continuous increase of conductivity with temperature (composite electrolytes, however, give a minimum resistance or maximum conductivity). (5) Metallic conductors show a continuous absorption and emission, while electrolytic salts, whether solid or liquid, show only selective absorption in the ultra-violet and ultra-red. The relation between conductivity and temperature in metallic conduction, from which by means of Van't Hoff's equation the energy of dissociation of the electrons from the metal can be deduced, is also discussed. The values deduced for these heats of dissociation are for the metals of the sodium and calcium groups below 100, for hydrogen above 500, for carbon in graphite and silicon 700 and 600, for the heavy metals below 20, for the non-metals well above 1,000. The values deduced for compounds are Fe_2O_3, 2,600; FeS_2 (pyrites), 480 (marcasite) 1,850; FeS, 1,500; Fe_3O_4, 1,600; SnS, 4,000; PbS, about 100; MoS, 2,800; CuO, 12,000; Cu_2O, 5,000; SiO_2, 22,000; AgS_2, 11,200. The limit for metallic conduction appears to be about 40,000, above which electrolysis is more likely to occur.

Not infrequently the medical journals revert to the danger of infection from talking into a public telephone. To overcome this apprehension a number of antiseptic mouthpieces have been fitted to transmitters. These usually contain some disinfectant that at the same time gives a pleasant odor to the mouthpiece. Where these are not provided a simple remedy has been suggested by Mr. Rosser S. Dean, who, writing in an English paper, says: "There has been some talk about danger of infection from the use of public telephones. May I suggest a simple contrivance by way of safeguard for those who care to use any? Fit a piece of thin but tough paper (good typewriting paper does well) over the mouthpiece of the transmitter, so as to form a little tight drumhead to it. If the paper be strong enough it will suffice to crumple it tightly round the neck of the cup, but a small elastic band holds better. The paper is fitted in a few seconds and removed as quickly. The user speaks against it, but without touching it. I do not find that the transmission of the voice is interfered with in the least. The idea is not mine, for I saw something of the kind on a neighbor's telephone and promptly adopted the idea for home use, but I think it will be new to most people, and may be welcome to some." By actual trial on a fairly good telephone line it will be found that this paper scheme does not appreciably detract from the


INTERNAL COMBUSTION ENGINE
STEAM ENGINE
THERMAL EFFICIENCY, —PER CENT.
GAS ENGINE
STEAM PLANT USING GAS
HORSE POWER DEVELOPED (BOTH PLANTS USING SAME AMOUNT OF BLAST FURNACE GAS)
GASOLINE ENGINE
STEAM PLANT USING COAL
COST OF ONE HORSE POWER-HOUR, —CENTS

RELATIVE EFFICIENCIES, HORSE-POWERS, AND COSTS.

clearness of the voice if the paper is put on tightly and is not too thick or too thin. A little pad of the paper can be readily carried by anyone willing to go to a slight inconvenience to allay nervousness in the use of a great public utility. While the bulk of the public enjoys the use of the telephone without trepidation, those who are scrupulous in this respect will probably find comfort in adopting the paper protector.—Western Electrician.

Enamel, Opaque, Green.—8 parts crystal glass (lead glass), 2 parts borax, 1 part oxide of tin, 1 part white calcined mutton bone, 1 part blue and 1 part green oxide of copper. According to the shade desired, the proportion of the two copper oxides is varied; add also ¼ to ½ part of chromic oxide and by this means obtain an attractive range of color.

*The Iron Age.

FERGUSON'S MECHANICAL PARADOX.

AN INGENIOUS TRAIN OF GEARS.

THE name of James Ferguson is probably unknown to most inventors and mechanical engineers; yet he was one of the most ingenious men of his time, and a distinguished member of the Royal Society. Ferguson was born in 1710, a few miles from Keith, in the little village of Banffshire in the north of Scotland. His father was a poor farmer, who could spend nothing on educating his children. Ferguson learned how to read by listening to the instructions which his brother received from his father.

As a shepherd, Ferguson studied the stars at night. In the daytime he amused himself by making models of mills, spinning wheels, and other mechanical contrivances. He even made a map of the stars.

After his term of servitude as a shepherd was over he entered the house of a country gentleman, Thomas Grant, whose butler, Alexander Cantley, according to Ferguson, "was a complete master of arithmetic, a good mathematician, a master of music on every known instrument except the harp, understood Latin, French, and Greek, and let blood extremely well, and could even prescribe as a physician upon urgent occasion." From this extraordinary butler, Ferguson received a good grounding in mathematics, geography, and grammar. Through the kindness of Lady Dippel he was taken to Edinburgh, where he stayed two years. By the time he was twenty-six years of age he had established himself as a portrait painter among the aristocratic class. For a time he had an inclination to become a physician, and studied anatomy and surgery. A brief experience as a physician in his native village convinced him that art was more to his liking, and accordingly he went to Inverness. Here he began to take up astronomy again. One of his first exploits was a plan for showing the motions and places of the sun and moon in the ecliptic on each day of the year perpetually, consequently the days of all the new and full moons. This plan was afterward engraved and published through the kindness of McLaurin, professor of mathematics at Edinburgh. Ferguson next made an orrery which showed the sun's motion on its axis, the diurnal and annual motion of the earth on its inclined axis, the motions and phases of the moon with the retrograde motion of the nodes of her orbit; and consequently all the variety of seasons, the different length of days and nights, the days of new and full moon, and eclipses. All told, Ferguson made seven orreries, in no two of which was the wheelwork alike. Later, Ferguson made a simple machine for delineating the moon's and the earth's paths on a long paper laid on the floor. The delineation and the method of doing it were exhibited to the Royal Society.

In 1747 he published a dissertation on the phenomena of the harvest moon, with a description of a four-wheel orrery. The favorable reception accorded this work prompted him to publish his "Astronomy," "Mechanical Lectures," "Tables and Tracts Relating to Several Arts and Sciences," "Young Gentleman's and Young Lady's Astronomy," a small "Treatise on Electricity," and "Select Mechanical Exercises."

After a time Ferguson was more or less constantly engaged in reading lectures on mechanics, hydrostatics, hydraulics, pneumatics, electricity, and astronomy.

Ferguson's best machine, in his own opinion, is his "eclipsareon," which shows the time, quantity, duration, and progress of the solar eclipses at different parts of the earth. His next best contrivance, in his own estimation, is the universally dialing cylinder.

It would appear that it was during the year 1750 that Ferguson invented and made his celebrated machine called "the mechanical paradox." In several of his works he mentions that he made it "on a very particular occasion," but without informing us of anything regarding this "particular occasion." But it is now certain that he made this curious machine for the purpose of silencing a London watchmaker who did not believe in the doctrine of the Trinity, as will be shown by a very interesting letter, written by Ferguson a few months before his death, to a clerical friend of his in the north of Scotland. The following is from Ferguson's own description of the machine:

"On a very particular occasion, about fourteen years ago, I contrived the mechanical paradox, which has been shown and explained to many, and which I shall here describe.

"It is represented in the annexed figure, in which *A* is called the immoveable plate, because it lies on a table whilst the machine is at work; *B C* is a moveable frame to be turned round an upright axis *a* (fixt into the centre of the immoveable plate), by taking hold of the knob *n*.

"On the said axis is fixt the immoveable wheel *D*, whose teeth take into the teeth of the thick moveable wheel *E*, and turn it round its own axis as the frame is turned round the fixt axis of the immoveable wheel *D*, and in the same direction that the frame is moved.

"The teeth of the thick wheel *E* take equally deep into the teeth of the three wheels *F*, *G*, and *H*, but operate on these wheels in such a manner, that whilst the frame is turned round, the wheel *H* turns the same way that the wheel *E* does, the wheel *G* turns the contrary way, and the wheel *F* no way at all.

"Before we explain the principles on which these

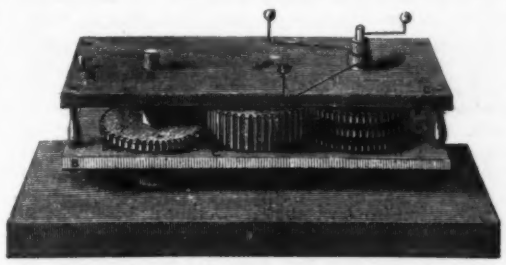


FIG. 1.—PERSPECTIVE VIEW OF FERGUSON'S MECHANICAL PARADOX.

three different effects depend, it will not be improper to fix some certain criteria for bodies turning or not turning round their own axis or centres, and to make a distinction between absolute and relative motion.

"1st, If a body show all its sides progressively round toward a certain fixed point in the heavens, the body turns round its own axis or centre, whether it remains still in the same place, or has a progressive motion in any orbit whatever; for unless it does turn round its own centre, it cannot possibly have one of its sides toward the west at one time, toward the south at another, toward the east at a third time, and toward the north at a fourth. This is the case with the Moon, which always keeps one side toward the Earth, but shows the same side to every fixed point in the starry heaven, in the plane of her orbit, in the time she goes once round her orbit; because in the time that she goes round her orbit, she turns once round her own axis or centre;—on the contrary, if a body still keeps one of its sides toward a fixed point of the heaven, the body does not turn round its own axis or centre, whether it keeps in one and the same place, or has a progressive motion in any orbit or direction whatever. This is the case with the card of the compass of a ship, which still keeps one of its points towards the magnetic north, let the ship be at rest or sail round a circle many miles in diameter.

"Both of these cases may be exemplified either by a cube or a globe having a pin fixt into either of its sides to hold it by. We shall suppose a cube, because its sides are flat. Sit down by a table, and hold the cube by the pin, which may be called its axis, and keep one of its sides toward any side of the room. Whilst you do this, you do not turn the cube round its axis, whether you still keep it in the same place or carry it round any other fixed body on the table; but if you

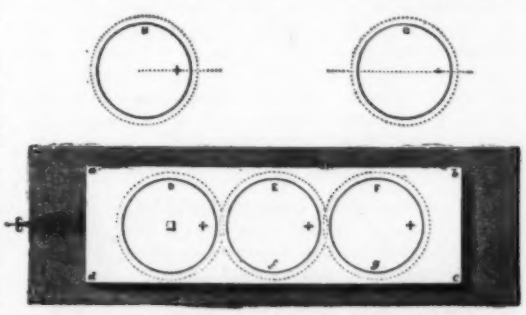


FIG. 2.—PLAN VIEW OF FERGUSON'S MECHANICAL PARADOX.

try to keep any side of the cube toward the fixed body whilst you are carrying it round the same, you will find that you cannot do so without turning the pin round (which is fixt into the cube) betwixt the finger and thumb whereby you hold it, unless you rise and walk round the table, keeping your face always toward the fixed body on the table, and then both yourself and the cube will have turned once round; for the cube will have shown the same side progressively round to all sides of the room, and your face will have been turned toward every side of the room, and every fixed point of the horizon.

"2d, If a ship turns round, and at the same time, a man stands on the deck without moving his feet, he is turned absolutely round by the motion of the ship, tho' he has no relative motion with respect to the ship; but if, whilst the ship is turning round, he endeavors to turn himself round the contrary way, he thereby only undoes the effect that the turning of the ship would otherwise have had upon himself, and is, in fact, so far from turning absolutely round, that he keeps himself from turning at all, and the ship turns round him as round a fixed axis, although with respect to the ship, he has a relative motion.

"Fig. 2 is a small plan or flat view of the machine in which the same letters of reference are put to the wheels in it as to those in Fig. 1, for the conveniency of looking at both the figures, in reading the description of them,—*W S E N* is the immovable plate; *E*, the thick moveable wheel, whose teeth take into the teeth of the wheel *D*; and *F* is one of the thin wheels, over which *G* and *H* may be put; and then *F*, *G* and *H* will make a thickness equal to the thickness of the wheel *E*, and its teeth will take equally deep into the teeth of them all. The frame that holds these wheels is represented by the parallelogram *a b c d*; and if it be turned round, it can give no motion to the wheel *D*, because that wheel is flat on an axis which is fixt into the immoveable plate.

"Take away the thick wheel *E*, and leave the wheel *F* where it lies, on the lower plate of the frame. Then turn the frame round the axis of the immovable plate *W S E N* (denoted by *A* in Fig. 1), and it will carry the wheel *F* round with it. In doing this, *F* will still keep on one and the same side toward the fixt central wheel *D*, as the Moon still keeps the same side to the Earth; and although *F* will then have no relative motion with respect to the moving frame, it will be absolutely turned round its own centre *g* (like the man on the ship whilst he stood without moving his feet on the deck), for the cross mark on its opposite side will be progressively turned toward all sides of the room.

"But if we would keep the wheel *F* from turning round its own centre, and so cause the cross mark upon it to keep always toward one side of the room, or like the magnetic needle, to keep the same point still toward one fixed point in the horizon, we must produce an effect upon *F* resembling what the man on the ship did by endeavoring to turn himself the contrary way to that which the ship turned, so as he might keep from turning at all, and by that means keep his face still toward one and the same point of the horizon. And this is done by making the numbers of teeth equal in the wheels *D* and *F* (suppose 20 in each), and putting the thick wheel *E* between them so as to take into the teeth of them both; for then, as the frame is turned round the axis of the fixed wheel *D*, by means of the knob *n*, the wheel *E* is turned round its axis by the wheel *D*; and for every space of a tooth that the frame would turn the wheel *F*, in direction of the motion of the frame, the wheel *E* will counteract that motion by turning the wheel *F* just as far backward with respect to the motion of the frame, and so will keep *F* from turning any way round its own centre, and the cross mark near its edge will be always directed towards one side of the room. Whether the wheel *E* has the same number of teeth as *D* and *F* have, or any different number, its effect on *F* will be still the same.

"If *F* had one tooth less in number than *D* has, the effect produced on *F*, by the turning of the frame, would be as much more than counteracted by the intermediate wheel *E*, as is equal to the space of one tooth in *F*; and therefore, while the frame was turned once round in direction of the letters *W S E N* on the immovable plate, the wheel *F* would be turned the contrary way, as much as is equal to the space taken up by one of its teeth; but if *F* had one tooth more than *D* has, the effect of the motion of the frame (which is turned *F* round in the same direction with it) would not be fully counteracted by means of the intermediate wheel *E*, for as much of that effect would remain as is equal to the space of one tooth in *F*; and therefore, in the time the frame was turned once round, the wheel *F* would turn on its centre, in direction of the motion of the frame, as much as is equal to the space taken up by one of its teeth; and here note, that the wheel *E* (which turns *F*) always turns in direction of the motion of the frame.

"And therefore, if an upright pin be fixed into the lower plate of the frame, under the centre of the wheel *F*, and if the wheel *F*, has the same number of teeth that the flat wheel *D* has, the wheel *G* one tooth less, and the wheel *H* one tooth more; and if these three wheels are put loosely upon this pin, so as to be at liberty to turn either way, and the thick wheel *E* takes into the teeth of them all, and also into the teeth of the fixt wheel *D*, then, whichever way the

frame is turned the wheel *H* will turn the same way, the wheel *G* the contrary way, and the wheel *F* no way at all. The less number of teeth *G* has with respect to those in *D*, the faster it will turn backward; and the greater number of teeth *H* has, with respect to those in *D*, the faster it will turn forward, reckoning that motion to be backward which is contrary both to the motion of the frame and of the thick wheel *E*, and that motion to be forward which is in the same direction with the motion of the frame and of the wheel *E*; so that the turning or not turning of the three wheels *F*, *G*, *H*, or the direction and velocity of the motions of those that do turn round, depends entirely on the relation between their numbers of teeth, and the number of teeth in the fixt wheel *D*, without any regard to the number of teeth in the moveable wheel *E*."*

* *Vide* "The Description and Use of a New Machine Called the Mechanical Paradox," invented by James Ferguson, F.R.S. London. 1764. Pp. 4-9. Also, Ferguson's "Tables and Tracts Relative to Several Arts and Sciences." London. 1767. Pp. 171, 172. Ferguson's "Select Mechanical Exercises." London. 1773. Pp. 46-57.

MARTYRS TO SCIENCE.

THE HEROISM OF THE PHYSICIAN.

BY T. C. BRIDGES.

IN September, 1906, there appeared in the British Medical Journal a letter from Dr. John Hall Edwards, president of the British Electro-Therapeutic Society, appealing for help—help in the way of suggested methods to cure himself of a cancerous growth caused by constant exposure to X-rays. The disease is known as X-ray dermatitis, and seems, by all accounts, to be one of the most cruelly painful maladies from which mankind can suffer. "I have not," wrote Dr. Hall Edwards in this letter, "experienced a moment's freedom from pain for more than two years, and at times the pain is so severe that I am rendered absolutely incapable of work, whether mental or otherwise. In the cold weather I am unable to dress myself, and the pain experienced cannot be expressed in words. On the back of each hand I have from fifty to sixty warts, many of them confluent. In order to excise these it would be necessary to remove the whole of the skin from the back of the fingers and from the greater part of the hands. Drugs have so far failed to give me the slightest relief. . . . The excruciating, ever-present pain appears to be due to a permanent irritation of the cutaneous nerves which nothing relieves, and which is intensified by holding the hands in a dependent position and by cold. The pain is of a neuralgic character, it never ceases, and is intensified from time to time by sudden stabs and jumps of such severity as to make one cry out."

Dr. Hall Edwards is one of the pioneers of the X-ray treatment. It was by the aid of a radiograph taken by him that the very first operation of the kind was performed. In 1900 he went to South Africa as radiologist, and published the results of his experiences with gunshot wounds. Soon after his return, the malady which has made his life one continuous torture first appeared. He understood well enough the ghastly threat, yet never for a moment ceased his work or experiments. He took to gloves and other forms of protection, but it was too late. The mischief was done, and nothing was found to stop the spreading of the ulcers.

Since that pitiful letter of two and a half years ago, the disease had become so much worse that it was found necessary to amputate the sufferer's left arm. Yet up to the very day previous to the operation the experimenter was at work in his laboratory, and at the time of the present writing his only fear is that he may not be able to complete his book on the subject for which he has made such amazing sacrifices.

Nor is Dr. Hall Edwards the only martyr to the mysterious and cruel influence of the Röntgen rays. In 1897 Dr. Clarence Daily, chief assistant in Mr. Edison's laboratory, did several weeks of experimental work during which his hands were constantly exposed to X-rays and to contact with highly fluorescent materials such as calcium tungstate. The first symptoms of injury were that his hands became inflamed as though scalded with boiling water, and his hair and mustache fell out. There was, however, no pain at the time, only slight soreness and numbness. Two years later cancer developed in the left wrist, and soon the other hand became affected. Everything was done that science could suggest. As many as one hundred and fifty pieces of skin were taken from his legs and grafted upon his hands, but all to no purpose. The disease went on spreading. Soon the left arm had to be amputated, next the sacrifice of the little finger of the right hand became necessary, and in June, 1903, three other fingers were taken off. Eventually the whole of the remaining forearm was removed, and artificial arms provided. The disease still continued to spread, and after seven dreadful years kindly death cut short the torment of life.

A third X-ray experimenter was the French doctor M. Radiguet, who died in December, 1903, after two years of similar sufferings. His last words were an expression of fervent thankfulness that he had been permitted to live long enough to establish reliable evidence as to the effect of the rays upon the human organism.

The list of victims to the deadly influence of the rays is by no means complete. There was Dr. Louis Weigel, one of the greatest American authorities on the subject, whose end came in June, 1906, after no fewer than seven different attempts by operation to save his life; Dr. Blacker, of St. Thomas's Hospital, who died in 1904; while many other experimenters and operators have suffered severely. Mr. Edison himself, upon whose mastoidal bone an operation has recently been performed, is said to have had the focus of one eye disturbed, and to have been afflicted with curious lumps upon the chest, the nature of which has not been diagnosed, but which are suspected to be due to the effect of the ray.

One can but hope and trust that operators will in future be able to protect themselves against the malign influence. Dr. Hall Edwards has shown that immunity can be obtained by the use of gauntlets lined with rubber and an apron coated with lead. But this does not alter the fact that the invaluable benefit conferred upon suffering humanity by the use of the rays has been paid for by torture unspeakable. All must do honor to the pioneers who have not hesitated to give more than life to the cause.

The pluck and self-sacrifice of the medical profession are proverbial. In the routine of his ordinary duty, more especially while engaged in research work, the doctor comes constantly into contact with all kinds of contagion and infection. Of course he takes precautions, but after all he is only human; he cannot always guard against the insidious attack of the deadly bacillus. A typical case is that of Dr. H. W. Syers, physician to the Great Northern Central Hospital. One day in October, 1906, while examining some organs in the post-mortem room of the hospital, he gave himself a slight prick—so slight that it did not even draw blood. Two days later the finger became painful, and was at once cut open and dressed. Too late! The poison, a virulent streptococcus bacillus, was thoroughly established in his system, and in less than a week he was dead. His is only one case among many. If the organs and tissues which have to be examined were sterilized, the work would be useless. They swarm with micro-organisms, and the slightest cut or scratch may mean death.

In certain cases where it is impossible to obtain knowledge second-hand, medical investigators have had no hesitation in experimenting upon themselves and in taking risks which to the ordinary layman seem madness. Being desirous of determining the amount of carbonic acid gas which, mixed with atmospheric air, formed an atmosphere dangerous to human life, Signor Teodoro Scribante, of Turin, offered himself as a subject. On three successive occasions he was confined in a hermetically sealed iron chamber the air of which was mixed with varying proportions of carbon dioxide. From a mixture of 1 part of the gas to 333 of air he progressed to one which contained 1.233 of the deadly choke-damp, and at the end of the third experiment was found in an unconscious condition and to all appearance dead. It was only by the use of oxygen that he was at last restored to life.

Not so dangerous perhaps, but certainly most risky and painful, was an experiment which resulted in an interesting paper read three years ago before the Royal Medical and Chirurgical Society. "A New Aspect of the Sensory Nerves" was its title. Its author, Dr. Head, F.R.S., stated that he had had the sensory nerves of his own arm divided, and watched the various sensations disappear. The nerves were reunited by stitching, and the progress of recovery carefully noted. As a result, Dr. Head discovered that there are two distinct sets of nerves to the skin, carrying different kinds of sensations. The first set convey the sensations of pain, also of heat and cold; the second set are those of touch which enable us accurately to localize our sensations. The healing power of the skin, he found, depends entirely upon the first set. These discoveries were deemed by the society so valuable that the Marshall Hall prize, given once only in five years by the society, was unanimously awarded to Dr. Head.

During the Spanish-American war the United States troops in Cuba suffered far more severely from yellow fever than from the bullets of their enemies. "Yellow jack" has been the curse of Cuba time out of mind, and a number of American army doctors at once instituted a campaign against the disease. A serum was discovered by Dr. Caldas which, it was believed, would counteract the effect of the fever germ, and volunteers were asked for who would permit themselves to be bitten by infected mosquitoes so that the effect of the serum might be thoroughly tested. A large number offered themselves, nearly all being doctors or nurses. As the inducement held out was the paltry sum of one hundred dollars, and it was stipulated that the subjects were to take all risks, it is hardly possible to suggest that those who came forward were actuated by any other motives than those of science and humanity. The experiments proved deadly. Two surgeons who permitted themselves to be bitten by mosquitoes fed on the blood of yellow fever patients died, one of them being Dr. Lazear, assistant surgeon to the military board. Miss Clara Maas, a trained nurse from Orange, N. J., was another victim. Her death occurred within seven days of having been bitten by two of the infected *anopheles*. Two medical students also caught the fever and came within an ace of death.

This question of the spread of infection by insects of different kinds has engaged the attention of the medical world for some years past, and at the present time scores of patient experimenters are in the field. The well-known German, Prof. Koch, recently spent eighteen months on a desolate island in the middle of Africa's great inland sea, the Victoria Nyanza, engaged in the investigation of that strange and terrible disease, the sleeping sickness. His only white companion was an army medical surgeon, and during the whole year and a half of his stay he saw but three other white men. A rough native canoe hewn out of a single log was his only means of communication with the mainland. The professor made the curious discovery that wherever crocodiles are found the disease may be discovered. The blood of crocodiles, he says, forms the chief nourishment of the *Glossina palpalis*, the insect which conveys the germs of sleeping sickness. Naturally, the ardent scientist ran considerable risk, but happily he has returned home in the best of health and spirits.

The worst scourge of our own country is tuberculosis, and fighting the "white death" has occupied the lives of many patient investigators. Some, like Dr. Robert Scott, have laid down their lives in the campaign. Dr. Scott, who lived at Grangerville, near Newcastle, made extensive experiments upon monkeys, inoculating them with tuberculosis germs, and afterward placing the animals in hermetically-sealed cells into which a breathing mixture largely composed of oxygen and ozone was pumped. Some were completely cured. Dr. Scott exhibited their lungs to a jury of medical experts, and convinced them that all traces of the disease had vanished. At last he himself contracted consumption, and, a firm believer in his own treatment, had a special "condensed pure air" chamber prepared for himself. Alas! He died a martyr, like so many before him, to his zeal for scientific research.

Of late years drug taking has become a very serious evil, especially among the well-to-do, and of all these stimulating poisons none has more terrible results than cocaine. With the object of investigating the cocaine habit, Dr. Winner, of Milford, N. J., an American physician of repute, began about five years ago a series of experiments upon himself. He would take large doses of the drug, and while seated before a mirror in brilliant light, calmly make notes of the color of the skin, the muscular action, and mental condition. A single quotation from these notes seems worth inserting: "July 18th.—Purchased one-eighth ounce cocaine hydrochloride. One grain boiled for three minutes produced only diaphoresis and local effects. Slept. Hallucinations at the end of twenty minutes, removed after one hour from the injection. Took a bath at five. No forced breathing; no convulsive movements of the muscles. Delirious in the occipital." Then follows a note as to the administration of an antidote which seems to have been successful. A few days later the unfortunate experimenter.

was discovered in a state of furious insanity, smashing the furniture in his rooms. He was taken to hospital, lapsed into unconsciouness, and died on the following afternoon.

It seems to be a fact that hardly any kind of scientific investigation is without its special perils. Little more than a year ago Dr. Robert Vance Freeman died from the effects of eating adulterated food. He was one of the famous "poison squad," men who volunteered to test various adulterated food products seized by agents of the American government. In January, 1904, Prof. Vincent Rodella, a well-known Italian scientist, was found dead in his laboratory, having unwittingly inhaled the fumes of a prussic acid compound which he was preparing. His age was only thirty. His portrait is in the hall of his university, with this inscription below it: "Died too young, but not without glory." Dr. Calmette, head of the Pasteur Institute at Lille, is another sufferer in the cause of science. While preparing his now famous snake serum he was bitten in the hand by a cobra, and only the amputation of the finger saved his life.

Descriptions of death by disease and poison are of necessity gruesome. It is a relief to turn to the records of explorers. Those who penetrate wild lands in the cause of science too frequently undergo terrible sufferings, and sometimes fall victims to their ardor. Yet pain or death, when one is facing the frosts of the Arctic, the sands of the desert, the dank heat of the tropic forest, or the spear of the savage, is not unexpected, and is therefore less repulsive than that which is incurred in the crowded haunts of civilization. How plainly the explorer foresees his possible fate was proved by a conversation between Andrée and Mr. J. Stadling, who stood by when the ill-fated balloon was ready to sail away into the unknown North, and who wrote the story later in the Century Magazine. "Suppose the balloon should burst, what then?" "We shall be drowned or crushed," replied Andrée. "When may we hope to hear from you?" "Not before three months at least. A year, two years may elapse. And if not—if you never hear from us—others will follow in our wake till the unknown regions of the North have been surveyed."

Arctic exploration is full of stories of intense suffering, of uncomplaining heroism, and self-sacrifice. It is very difficult for one who has never traveled beyond the Arctic circle to picture even faintly the sufferings which result merely from climatic conditions in the far North. A few lines from Lieut. Peary's description of his crossing of Greenland give just a glimpse of them. The wind, he says, is never at rest on the "Great Ice, and always it carries an ice-drift a foot or two in depth. In the savage blizzards of a frozen Sahara this drift becomes a roaring, hissing, blinding Niagara of snow, rising hundreds of feet into the air, a drift which almost instantly buries any quiescent object, and in which it is almost impossible for the traveler to breathe. Even when the depth of the drift is not in excess of the height of the knee, its surface is as tangible and almost as sharply defined as that of a sheet of water, and its incessant, dizzy rush and strident sibilation become, when long continued, as maddening as the drop, drop, drop of water on the victim's head in the old torture rooms."

In 1902 Mr. Dillon Wallace and Mr. Leonidas Hubbard made an unsuccessful attempt to cross the huge, barren peninsula of Labrador. Food ran short, there was no game, and their sufferings became terrible. "Our bones," writes Mr. Wallace, "were sticking through our skins. Hubbard and I were like walking skeletons. Hubbard grew so weak that he could not proceed farther, and we left him wrapped in a blanket, and pressed on in search of food." When they returned he was dead!

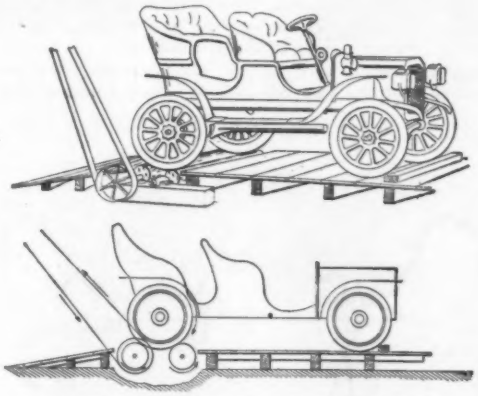
There is probably no explorer alive who has suffered more physical hardship than Dr. Sven Hedin, that plucky Swede to whom we owe nearly all our knowledge of the geography of northern Tibet. The story of his race in the desert against death by thirst is too well known to be repeated here. It is, however, doubtful whether his sufferings on that occasion exceeded those on his journey from Charlik to Ladakh, when he passed through valleys far higher than the summit of Mont Blanc. At these enormous altitudes the mere act of breathing became a matter of such difficulty that on this one trip four of his companions died simply because they were unable to breathe. When they came to their camping ground one evening two were found stark dead on their camels. The others "died gradually, from their feet upward, retaining their senses to the end."

"The experience," he writes, "was weird and awful, and certainly the worst I have ever had. I was not affected to the same degree; but I was quite unable to march, and had to remain immovable in the saddle all day. Even to unbutton one's coat meant acute pain and tension to an overwrought heart, which literally was at the point of breaking. . . . During the whole of this one journey of a thousand miles icy gales blew in our faces the whole way."

One would like to dwell on the bravery of the heroes who have faced the waterless deserts of inner Australia, that Never-Never Land of granite, spinifex, salt lakes, and mirage; to picture the trials of the explorers who have followed the endless monotony of the bush paths which wind through the heart of Africa's vast forests; to touch on the enormous difficulties faced and overcome by those who first mapped out the gigantic watersheds of the Amazon and the Orinoco. But space does not permit, and one may fitly close a paper of this kind with a brief description of the dangers braved by Mr. G. C. Curtis, the first man who reached the summit of Mont Pelée after its terrific eruption. In the cause of science this man actually descended into the crater, although at the time it was still in a state of active eruption. Mist, rain, steam, and dust made an atmosphere through which it was impossible to see more than a few yards; but other senses than that of sight gave warning of the surrounding perils. The atmosphere reeked of sulphur, so that breathing was almost impossible. Constant crashes like the firing of heavy cannon proceeded from the depth in front, while at frequent intervals masses of ejected rock fell close and rolled clattering and clinking back down the precipitous slopes. One explosion was so close that the heat scorched the face of the bold observer." It was during their return that he and his companions had their narrowest escape. A great mass of blackish liquid mud was suddenly ejected and went rushing down a ravine immediately in front of the party. Crested with huge boulders, this ten-foot wall of mingled earth and water went hurtling down the mountainside, cutting away the rocks as though they had been paper. The roar was absolutely deafening and the ground shook so continuously that Mr. Curtis was barely able to keep his feet. A few yards farther on and they must have been overwhelmed. It was a stroke of good fortune that saved the explorers from a sudden and appalling end.—Chambers's Journal.

THE AUTOMOBILE ON THE FARM.

WITH the coming of the automobile to the farm what could be more natural than the desire to utilize its splendid power plant for other purposes besides that of propelling itself over the roads? An ingenious farmer has solved the problem in a manner apparently satisfactory to himself.



AN INGENIOUS WAY OF USING THE AUTOMOBILE.

His dairy and barn being over a mile from his home, he uses an automobile, a medium-priced touring car of standard make. His first attempt at running the dairy machines, separator, churn, etc., was to run a belt from one of the jacked-up wheels of the car, the belt running on the curved surface of the pneumatic tire without trouble. This arrangement, however, caused undue wear on the differential by reason of one wheel's doing all the turning, and was otherwise objectionable on account of the inconvenience of lining up the car every time to make the belt run properly.

To overcome these objections, our ingenious friend devised an arrangement whereby the act of putting the car in its shed places it in position and so associates it with the machinery of the dairy that it is sufficient to start the engine, throw in the high gear, and regulate the speed to the load.

The accompanying sketch shows this device so plainly that it is not necessary to describe it other than to call attention to the two rollers, one of which has its shaft extended outside the box to carry a pulley from which the belt runs to an overhead shaft. It is easily apparent that the revolution of the wheels of the car will cause a reverse motion of the rolls which is transmitted by means of the pulley and belt to the shaft and thence to the machinery.

In this way the wear on the tires is rendered uniform and that of the differential eliminated entirely. The grip on the rolls that these tires exercise is surprising.

A peculiarity of this arrangement is that the car shows a tendency to skid from side to side. This, however, is easily overcome by means of props or bumpers which are put in place so as to limit the sidewise motion of the car within the shed, the mere pressure of the hand serving to move the car easily when the wheels are revolving on the rolls.

In very warm weather or on long, heavy pulls, it is sometimes necessary to connect the circulating system with the water supply in order to prevent heating of the cylinders.

For sawing wood, cutting feed, or any work of an intermittent nature, it is necessary for someone to control the engine on account of there being no governor. As a matter of fact, our farmer has a small boy at the throttle most of the time as the separator is sometimes thrown off without warning.

The above shows how one man, at least, is getting good work out of his automobile, bad roads and bad weather notwithstanding.—American Machinist.

THE ORIGIN OF SUBJECTIVE HEAD NOISES.

SUBJECTIVE head noises, or auditory sensations which are not caused by aerial sound waves, are often described as the most distressing symptoms of chronic diseases of the ear. For many patients these noises are almost maddening, and in some cases it has been deemed advisable to prevent them by destroying the labyrinth of the ear. It is generally assumed that these noises are caused by some abnormal and internal stimulation of the auditory nerves. Brenner has produced auditory sensations by electrical stimulation of the nerve, but stimuli of this character are necessarily of brief duration, and Werkovsky deems it impossible for a succession of them to cause noises which are heard continuously for years.

Dull, muffled sounds are produced by the contraction of the muscles of the face and neck, in chewing, turning the head, etc., but these sounds continue only during the muscular action. The continuous noises are caused chiefly, as Hippocrates, "the father of medicine," asserted, by the intermittent flow of blood through the numerous blood vessels in and around the ear. We are so accustomed to these sounds that in ordinary conditions we are unconscious of them, as we are of the weight of the limbs. Zwaardemaker found that subjective noises were heard even by persons with normal ears, when they were placed in perfectly sound-proof rooms. Werkovsky also thinks that, in ordinary conditions, subjective noises cannot be explained by immediate stimulation of the auditory nerve, but that every subjective noise has an objective cause, located in or near the ear. The continuous and persistent hissing and whistling sounds, which are especially distressing to the patient, are always caused by the flow through the blood vessels. They may be quite normal, in their origin, but unusually perceptible, owing to nervous irritability or abnormal sound-conducting power of the bones. On the other hand, these noises may be pathological in their origin, and due to alteration in the composition of the blood (as in anæmia), degeneration of the walls of the blood vessels, constriction of the blood vessels, etc. Thus they may give indications for the treatment of the disease. Both examination and treatment should be constitutional as well as local.—Umschau.

Water-proof Paper.—I. According to the patent of a German concern, dissolve in the water bath 1 part of white glue in 4 parts of water, to which 1 part of glycerine is added. In a separate vessel dilute ¾ part of commercial formol with water, to 5 parts. Both sides of the paper are coated with the glue solution; dip it, after a time, into the formol solution and dry it. On such a glue coating even steam under pressure is said to exercise no effect. II. According to Dreseu's French patent, 28 parts each of common olive oil, rape oil, and linseed oil are mixed and to this mixture 8 parts of wax dissolved in 8 parts of turpentine added. This mixture is applied to one or both sides of paper by hand, or with the aid of a coating machine. This paper is said to remain waterproof longer than other commercial water-proof papers. III. According to the Hornung patent, the paper is coated with the following described coating or impregnating mixture, or the latter may be directly added to the paper pulp. The mass is composed of 25 parts each of albumen or gluten and water, 0.25 part salicylic or carbolic acid, 3 to 10 parts of rubber, gutta percha, or a substitute substance. If a flexible paper is desired add 5 to 13 parts of glycerine, syrup, fat, oil, or oil-gum. The albumen is dissolved in water, caused to coagulate by heating, and after it has settled the water is poured off. The rubber, to which some sulphur has been added for vulcanization, is dissolved in a suitable solvent and the above described constituents without the albumen thoroughly mixed and then heated to the vulcanizing temperature. After cooling the albumen is added and the substance thus produced thinned with turpentine, benzine, etc., and applied to the paper to be waterproofed. The paper pulp can also be thoroughly impregnated with this saturant and then made up into paper.

THE FUTURE OF THE EARTH.

IS THE SHAPE OF OUR GLOBE CHANGING?

BY ABBÉ MOREUX.

UNTIL Lowthian Green, about forty years ago, enunciated a general theory of the formation of continents, the positions of the lines of elevation had been regarded as almost fortuitous. In 1902 I pointed out the applications of Green's theory to the theories of volcanoes and earthquakes.

Fig. 1.—The tetrahedral form which the earth assumed in cooling.

The earth, contracting as it cooled, became deformed like a collapsing balloon, showing a tendency to assume the form of a tetrahedron. Three of the faces of the tetrahedron are represented by the Atlantic, Pacific, and Indian oceans, and three of the apices by the Canadian, Baltic, and Siberian plateaus. From these summits, all far north and very ancient, as their primitive rocks attest, three ridges, corresponding to edges of the tetrahedron, extend in converging, irregular, and more or less interrupted lines to the Antarctic Continent, which represents the fourth apex, while the fourth face is represented by the great Arctic basin, the existence of which was established by Nansen.

These edges and summits have remained fixed during subsequent deformations, which may be divided into three classes:

1. The center of each face has fallen inward, following the contraction of the core.

2. Lateral compressions, fractures, and upheavals have taken place near the edges.

3. As the crust thickened, the slopes which meet in the edges have shown a tendency to dislocation—hence these are the earthquake regions.

In the course of ages other great ridges were developed, usually at right angles to the primary edges.

Now let us study the effects of these various displacements. Fig. 4 represents a vertical transverse section of a plane of fracture and a ridge parallel to it. The pressure being very great at *a* and *b*, and very small at *c* and *d*, molten matter entering at *c* will escape at *d*, at the top of the ridge. Hence mountain chains bordering the great lines of fracture are volcanic regions.

The adjacent slopes tend to follow the central parts

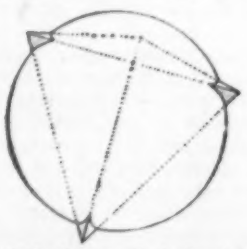


Fig. 2.—A tetrahedron partly inclosed by a sphere.

of the faces of the tetrahedron in their descent and are, consequently, subject to earthquakes.

A glance at the globe on which the apices and edges of the tetrahedron have been marked (Fig. 1) shows that the continents have been formed about these rigid supports and that the volcanoes, active and extinct, are distributed along the lines of fracture. This is shown also by the maps (Figs. 5 and 6) on which the three north-and-south edges, like the meridians, appear as parallel lines. The first edge (Fig. 5) is bordered by the great American volcanic belt extending from Alaska to Cape Horn, and represented by the irregular black line. Bordering the second edge, still more irregularly, are the volcanic districts of Iceland, Jean Mayen, Auvergne, Sicily, and East Africa. A third volcanic belt, which joins the first at the Aleutian Islands, borders the third edge of the tetrahedron, and includes the volcanoes of the Kunle Islands, Japan, the Sunda Islands, and New Zealand.

Fig. 3.—A fracture of the crust.

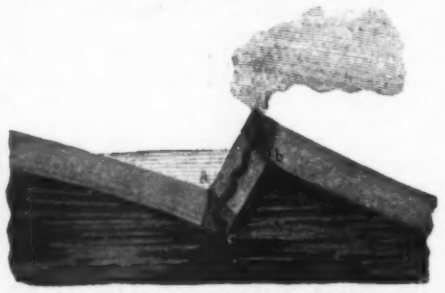


Fig. 4.—Transverse section of plan of fracture and volcanic ridge.

The three belts meet in the Antarctic Continent, where the volcanoes Erebus and Terror are situated.

It will be observed that these three edges of the tetrahedron do not run exactly north and south, but that their southern ends trend to the east. Every planet rotates more rapidly as it contracts. The three northern apices were formed very early and their distance from the axis has retarded their rotation relatively to that of the southern hemisphere. The result is a dislocation represented by the great equatorial furrow known as the "Mediterranean depression," which extends from the Antilles to the Pacific, through the Mediterranean, the Persian Gulf, and the Sunda Archipelago, and constitutes a zone of weakness and of volcanic disturbance. This zone is indicated by the curved equatorial line (Figs. 5 and 6).

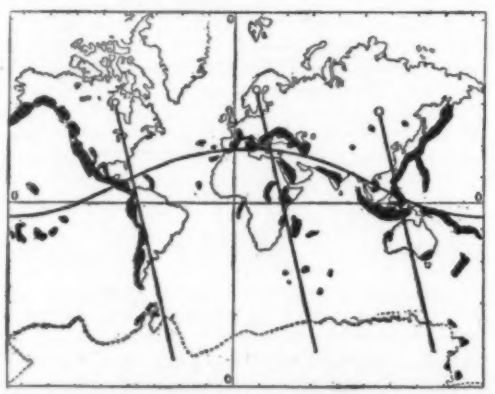


Fig. 5.—The three primary edges, or lines of fracture, the contiguous volcanic belts, and the "Mediterranean depression."

The earthquake regions are represented by the shaded areas in Fig. 6. They are far more extensive than the volcanic regions, as the theory demands, and they are, to a considerable extent, independent of volcanoes and intimately associated with the steep and extensive slopes of the earth's surface. In general, the centers of disturbance are near sea coasts bordering the high mountain ridges, but neither earthquake nor volcanic eruptions are caused by seepage of water.

Our sensitive seismographs record an average of

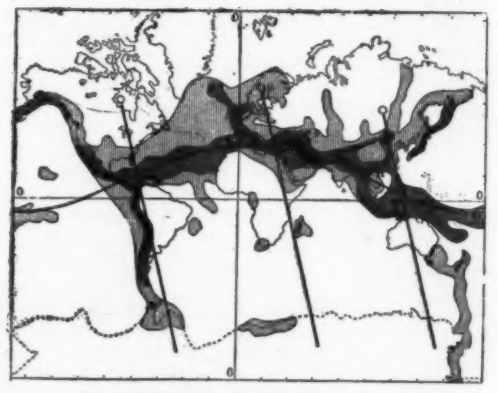


Fig. 6.—Earthquake regions (shaded).

30,000 shocks per year, showing an almost continual state of tremor, but severe earthquakes occur more rarely and in groups which often extend over weeks. Earthquakes are more frequent in winter than in summer, in the proportion of 3½ to 1. They are also more frequent in the night and morning than at other hours. Atmospheric electricity follows the same law of periodicity that is observed in the case of earthquakes. Terrestrial electric and magnetic phenomena are governed by the sun and it seems probable that earthquakes and volcanic eruptions are similarly dependent on solar activity. Eruptions occur most frequently at intervals of eleven years, at epochs of minimum solar activity, while earthquakes occur chiefly at

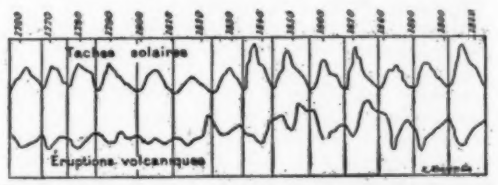


Fig. 7.—Curves of solar activity (above) and volcanic activity (below).

the epochs of most rapid increase and decrease of solar activity. This law, which indicates that eruptions and earthquakes have no direct connection, has enabled me to predict the recent severe earthquakes, and the gradual diminution of earthquakes until the next minimum of solar activity, in 1911-1912, when volcanic eruptions will increase.

The explanation of the periodicity of earthquakes and eruptions is equivalent to the discovery of a periodic cause of contraction and expansion of the earth's crust. The variability of solar heat will not suffice, for we know that the temperature of the earth at depths greater than 50 feet remains very constant. A more probable cause is found in the variable electric

Fig. 8.—Europe as it is.

Fig. 9.—Europe as it will be.

charge of the earth. It is a fact not generally known that the volume of a Leyden jar is increased by charging the jar and diminished by discharging it, wholly or partially. The crust of the earth resembles a Leyden jar, of which the coatings are represented by the liquid core and the enveloping atmosphere. The atmospheric charge and potential undergo diurnal fluctuations, falling during the night and early morning and attaining maximum values shortly after midday. We have seen that earthquakes occur chiefly during the night and morning, when the solar radiation and electric charge are least and the contraction and internal pressure greatest. In the afternoon the increased charge causes a dilatation, as in the Leyden jar, the pressure is relieved, and the quakes abate. A similar parallelism exists between annual and eleven-year fluctuations of seismic and volcanic phenomena, and those of solar activity and atmospheric electricity.

What will become of the earth after the crust has become too thick to yield to these periodic forces? Convulsions far more terrible than any now experienced may be expected. The scarred and desert moon presents a plausible picture of the earth's ultimate fate. This fate is very remote, but the intermediate stages are sufficiently awe-inspiring. In Fig. 6 is shown a dark gray band of intense seismic activity, extending from Sicily, through Italy and France, to Iceland. The whole of France is near the primary line of fracture indicated by the extinct volcanoes of Auvergne, and slight shocks occur almost incessantly throughout the country. Furthermore, France is very near the Mediterranean depression and the great fold of the Alps, which is of so recent formation, that it would be rash to assume that it is completed. The reawakening of volcanic activity in France will be terrible. The recession of the southern coast, already in progress, will go on rapidly until the Mediterranean is connected with the English Channel. Spain will be an island and the greater part of France and of Great Britain and Ireland will have vanished from the map of Europe.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from L'Illustration.

THE MIMICRY OF PLANTS.*

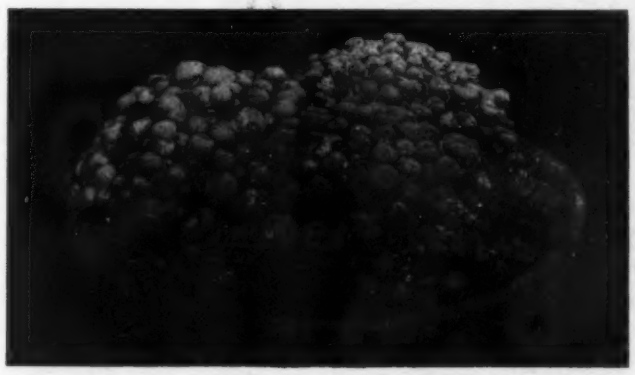
SOME CURIOUS RESEMBLANCES.

BY S. LEONARD BASTIN.

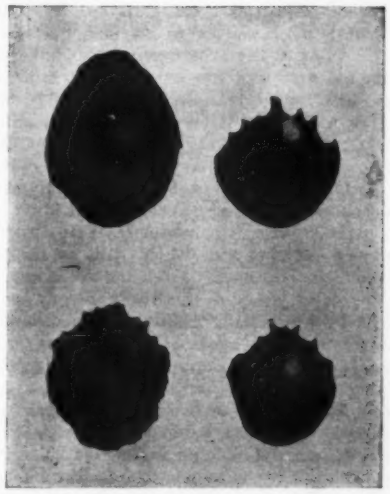
IT is often in the very beginnings of a being's existence that the most need arises for special protective means and it is therefore not surprising to find that quite a number of seeds are examples of mimicry. Doubtless many of these resemblances are purely accidental, but in others one cannot but think that there is a real purpose in the simulation. Many seed vessels bear an astonishing likeness to beetles and other insects, one of the best known perhaps being that of the castor oil plant (Ricinus). This, although not large enough to make an effective photograph, is singularly suggestive of the widely distributed Coccinella beetles and their allies. The large seeds of the genus Chelonospermum, from the Pacific Islands, are wonderfully like some of the huge tropical Coleoptera. As Lord Avebury has pointed out, these resemblances might well benefit the plants in one of two ways. It might be an advantage for the smaller kinds of seeds to be swallowed by birds, the external coating being able to withstand the action of the digestive juices. It is not difficult to conceive that a large number of seeds mimicking beetles in appearance must be eaten by birds, under the impression that the morsel is a succulent insect. On the other hand, the big seeds, such as those of Chelonospermum, might escape unwelcome attention by their likeness to insects. Graminivorous birds, which would tear the seeds in pieces and destroy them, mistaking the vessels for formidable beetles, would avoid tackling them, and thus they would remain untouched.

Some of the most amazing plants in the world are certainly those to be numbered among the South African Mesembryanthemums. If there is nothing in the theory of protective resemblance as applied to plants, these quite defy all explanation. Glance at the accompanying photograph of a potted specimen of Mesembryanthemum truncatum. It is absolutely impossible to distinguish between the succulent shoots which form the plant and the pebbles surrounding it. The very coloring of this strange specimen is devised so as to further the illusion. In another species, although it does not make quite so striking a photograph, the resemblance is none the less remarkable in the living plant. It is necessary to consider the conditions under which these strange plants live to find a satisfactory reason for this simulation of rock and stone. Perhaps there are no two regions in the world so much alike as the desert lands of South Africa and those of New Mexico and Arizona. In both these districts vegetation can only exist by special modifications of growth; these usually take the form of a reduction or total abandonment of foliage and evolution of thick, fleshy stems. Now succulent plants, storing up a quantity of sweet juice for their own consumption, are always liable to the attack of parched and thirsty animals in a dry country. The American Cacti are armed with terrific arrays of thorns, but the African Mesembryanthemums have a stranger, but quite as effective, mode of protection. These ingenious plants simply rely on not being seen at all, and it is likely that in their extraordinary simulation of en-

Mesembryanthemum truncatum from South African deserts.



Stone mimicry. Mesembryanthemum from South Africa.



Beetle-Ski seeds. Chelonospermum from Pacific Islands.

* From American Homes and Gardens. Published by Munn & Co.

The dragon Arum, a huge crimson flower with a scent of decaying meat.

An orchid resembling a moth. The Catasetum from South America.

The Aristolochias is strongly suggestive of decaying meat.

Some species of the Iris are called "roast beef" plants from the odor they emit.

THE MIMICRY OF PLANTS.

vironment there is a security upon which it would not be easy to improve.

It is very important on occasion that certain plants should be able to advertise their presence. Somehow or other a vast number of species have become more or less entirely dependent upon the good offices of insects to assist them in their scheme of fertilization. Of course, the insect goes to the flower solely for what he can get, or imagines he will find there. The great thing from the plant's point of view is to induce the visitor to pay his call. To this end it is proved that some plants in their flowers aim at a definite simulation of carrion-matter which is calculated to attract hordes of insects. The well-known dragon arum is a case in point.

This plant, which is a native of Southern Europe, and an easy subject for the garden, produces giant flowers, typical of its kind. These are colored on the inside of the spathe with a most lurid crimson, very suggestive of decaying meat. Moreover, the shining black spadix rising from the center of the bloom adds yet further to the striking appearance of the plant. Just as the spathe develops, a most disagreeable odor is emitted, strangely suggestive of rotting flesh. So genuine is this illusion that the writer knows of actual cases in which the plant has been banished from the garden simply because the owner could not endure the unpleasant scent. To the insect world the suggestion is no less deceiving, for large numbers of flies are attracted to the flower in the hope that they may be able to feast on the carrion. By an ingenious arrangement many of them are entrapped for a while, and held captive until they have become well dusted with pollen.

There are perhaps few more wonderful flowers in the world than those produced by the South American Aristolochias; these are so huge as to represent almost the largest blooms in the world. Many of the species are authoritatively stated to lure insects by means of the resemblance which they bear to carrion. In particular A. gigas is strongly suggestive of decaying meat, while when the blooms are in perfect condition they send out an odor so unpleasant that it is difficult to stay in a hot house with them without discomfort. Another species of the same genus, A. tricaudata, is of deep purple in the tinting of its flowers, while each blossom has three long appendages, giving the appearance of the drippings which might arise from a piece of meat suspended in the air. All these Aristolochias are visited by large numbers of flies, on whose agency the plants largely depend for the cross-fertilization of their organs.

The above examples are extreme instances of the simulation of carrion by flowers, but there are a very large number of plants which produce blossoms smelling suggestively of rotten meat. Some species of Iris, although they cannot be said to resemble carrion in their appearance, are certainly very strange in their odor. One of these, common in Europe, has been given the name of "roast beef" plant on account of its scent, which is said to resemble that of cooked meat. Most people would feel, however, that that flower scarcely smells of anything so wholesome. As a general rule it will be found that the majority of brown or luridly colored flowers give off an odor which is not pleasant to human beings, although it must prove very attractive to flies.

A particular phase of plant simulation which has never been satisfactorily explained is that which is quite common among orchids. In these cases the whole appearance of the flower is suggestive of some insect—to quite a remarkable degree in some instances. It does not seem easy to suggest any real purpose that could be served by this resemblance, and yet one can scarcely think it to be accidental. Probably one of the most curious examples is the bee orchis (Orchis apifera), a native of Europe. Anyone who knew of this orchid, and came across it for the first time, would have small difficulty in at once recognizing it. The labellum is of a velvety brown variegated with yellow, while the two lateral petals might very well serve for the wings of the insect.

Nearly related is the fly orchis, a most singular plant in the peculiar form of its flowers. These are somewhat small, and in the center of the lip there is a small bluish spot, like the body of a fly; the two lateral petals are very slender and curiously like the antennæ of an insect. The whole illusion is very complete, and a casual glance suggests that a few flies are hanging on to the stem of some plant which has cast its flowers. Of course, among the exotic orchids there are many which by their strange shapes suggest some insect or other. The New World Catasetums are very curious in this respect, and a picture of a spray of bloom which is reproduced very much resembles a number of moths with partly closed wings. Other instances might be cited in the orchid family of this kind of simulation, and it would be a very easy matter to fill pages with descriptions of these weird flowers.

Of course it is freely admitted that in these similarities shown by orchid flowers there may be nothing of any meaning; in the way that they appear to us the likenesses may serve no end at all. Nevertheless it is rather significant that there should be so many cases of this nature found in one tribe. It has been hinted that perhaps the special insects which the orchids mimic are not desired to visit the flowers. Any call is discouraged, by making it appear to passing insects that the bloom has a visitor already. This certainly seems to be rather a far-fetched theory, but it is really impossible to say that such a state of affairs might not have been brought about by means of natural selection.

DR. SVEN HEDIN ON CENTRAL ASIA.*

THE RECORD OF A GREAT ACHIEVMENT.

THE April number of the Geographical Journal contains two papers by Dr. Sven Hedin descriptive of his journeys through Tibet in 1906-8. The first of these is a narrative of his travels, which is necessarily so much abridged that it barely does more than give an idea of the extent and difficulties of his exploration; the other is a summary of the most important, or, rather, what Dr. Hedin regards as the most important, of his discoveries. The two are not necessarily identical, and it may be that when we have the full account of his travels the discoveries to which he now attaches greatest importance may prove of minor interest. For the present, however, we have only this summary, in which he enumerates the four most important results of his journey as the discovery of (1) the true source of the Brahmaputra, (2) the source of the Indus, (3) the "genetic" source of the Sutlej, and (4) the discovery of a continuous mountain chain, to which he applies the name Trans-Himalaya.

Of these the first two are of interest, especially the fact that no part of the drainage of the Kailas mountain finds its way into the Indus River; the third is a doubtful discovery, for though Dr. Hedin has discovered and visited the source of the largest of the feeders of the Manasarowar Lake, it cannot in any proper sense of the word be regarded as belonging any longer to the drainage area of the Sutlej River. At one time there was continuous flow from Manasarowar to Rakas Tul, and again from that to the Sutlej, but this latter has been dry for at least half a century, while the former seems to have become intermittent and likely to cease in the near future; except for a possible escape by underground percolation, no part of the water of these lakes now finds its way into the river, and even this suppositious communication would not justify us any longer in describing a tributary of either of the lakes as the source of the Sutlej, nor does the matter seem much bettered by the addition of the adjective genetic.

The most important, in his own view, of Dr. Hedin's discoveries, and the one around which controversy has settled, is that of a great continuous mountain range, coextensive with and parallel to the Himalayas, to which he has given the name Trans-Himalaya, a name to which exception has been taken, and which seems to require greater justification than Dr. Hedin has given. We may ignore the objection that the term was applied by Cunningham to the mountains lying between the Sutlej and the Indus, but we cannot accept the quotations from other authors cited as justification for the use of the term. A writer from the Indian side may use, with perfect correctness, the expression Trans-Himalayan, as applied to the country, or to explorations carried out, on the farther side of the Himalayas, but it is a different matter when we are asked to accept the words as a definite geographical term, and once this proposal is brought forward the two questions arise as to whether the word is either justifiable in itself, or necessary. Of these two questions the first is a literary one, and it must be confessed that some real objections may be urged against the word adopted by Dr. Hedin, and accepted by Lord Curzon of Kedleston; but the second is the important one, for, unless the supposed range of mountains to which it is applied has a real individuality and independent existence, no special term is required.

From earliest times it has been recognized that the great system of mountains which rises to the north of the Indo-Gangetic plain has an individuality of its own which deserves and requires a name, and the word Himalaya, originally applied to a part, has been extended to the whole chain of snowy peaks together with their dependent mountains of lower elevation. It has not, however, been so generally recognized that this unity belongs less to the mountains than to the plain at their foot, and some modern geographers, not content with merely recognizing the individuality of the great chain, have attempted to trace the individual ranges of which it is composed along the whole length of the system, and thereby have retarded a proper appreciation of the true nature of this system of mountains. A simile proves nothing, but is often useful as an illustration, and, without pressing the resemblance too far, the organization of the Himalayan Mountains may be compared to that of a great army, composed of many thousands of individual soldiers, grouped in regiments, these, again, in brigades and divisions, each having a separate individuality; but the individuality of the soldier differs from that of the regiment to which he belongs; this, again, merges in the individuality of the brigade, and the whole in that of the army. So with mountains, the peaks may be grouped in *massifs*, these into ranges, a series of which may form a great chain or system like that of the Himalayas or the Andes; but just as the brigades of an army are not each extended along the whole front, so the ranges do not extend along the whole length of the system. Each in turn comes to an end, and the chain is taken up by another, not as a direct continuation, but overlapping the end, so that the direction of the individual ranges is oblique to that of the system as a whole. Any other arrangement would probably be as physically impossible, with material such as that of which the earth's crust is composed, as the marshaling of an army in brigades or divisions drawn up in lines extending along the whole length of the front would be militarily impracticable.

This interpretation of the orography of the Himalayas is borne out by such maps as we possess, and especially by those maps attached to Messrs. Burrard and Hayden's valuable sketch of the Himalayas, which exhibit the facts, rather than Col. Burrard's interpretation. In these it will be seen that the high peaks of the Himalayas do not form a single range, but rather a band crossed obliquely by a series of ranges, and if we are to group these individual ranges into a single system, and to include in it the lesser ranges lying to the north and south, there is no reason, geographical or geological, for separating it from the mountains of southern Tibet and the northern territories of Cashmere. Structurally and orographically, the whole of the mountains between the Indian plains and the lake region of central Tibet belong to one great system, and the term which Dr. Hedin wishes to introduce is either unnecessary or misleading; needless if it merely indicates the country north of the first belt of lofty, snow-clad peaks, misleading if meant as a name of a mountain range or system. Range it is not, for Dr. Hedin is clear enough on this point, as he repeatedly speaks of the separate ranges of which it is composed, and gives their number as no less than ten; mountain system it equally is not, having no separate existence. If a new name is required at all, it must be one which will unite these ranges with the Himalayas, not one which suggests a separation, for the valleys of the Sanpo and Indus no more separate the mountains on either side of them than, on a smaller scale, are the analogous valleys of the Rhone and the Rhine a reason for splitting up the unity of the Alps.

This criticism must not be taken as in any way a disparagement of Dr. Hedin's achievements; there can be but one opinion of the brilliance of his exploration, and of the courage and determination with which he overcame the obstacles in his way. The publication of a detailed account of his travels will necessarily form an important addition to our knowledge of central Asia, but the fullest recognition of its importance does not involve an acceptance of Dr. Hedin's deductions, nor does a difference of opinion in regard to them imply any question of the accuracy of his observations.

* Nature.

Red Ink for Laundry Marking.—Neutralize 5 parts of sesqui-carbonate of ammonia with nitric acid in a porcelain mortar; the perfectly neutral solution is rubbed down with 3 to 4 parts of carmine. As a mordant for linen, use a mixture of equal parts of solutions of acetate of alumina and nitrate of tin. The linen or cotton articles, which have previously been treated with this preparation, after thorough drying out of the mordant, are marked with the carmine ink.

ASTRONOMICAL OBSERVATIONS.

HOW THEY ARE MADE.

BY G. DEVAULAY.

WHEN we glance back over the astronomical observations which have been made from the most ancient times to the present day, we are surprised by their precision, especially when we remember the methods and instruments by which they have been made.

The earliest astronomical observations of which we have any record were made by the Chinese. The Chou-King, the oldest known scientific work, informs us that, two thousand years before our era, the Chinese determined the seasons, that is to say, the positions of the sun at the equinoxes and solstices, by means of four stars which have since been identified and found to be so suitable that a modern astronomer could not have made a better choice. The Chinese also determined, eleven hundred years before our era, the obliquity of the ecliptic, which they found equal to 23 deg. 54 min. The obliquity, which varies, is now 23 deg. 37 min., and calculation shows that at the epoch of the Chinese observations it must have been 23 deg. 51 min. Hence, the error of the Chinese determination was only three minutes of arc.

Among the few astronomical values which have remained constant during the history of man are the times of revolution of the planets. The Hindus determined the revolution of Mercury with an error of 4/10,000 of a day. For Venus the error was 23/10,000 of a day; for Mars, 1/1,000 of a day. In the case of Jupiter, the error amounts to ¼ of a day, but we must remember that the period of revolution of this planet exceeds 11 years, and that the same observer could not observe many returns of the planet to the same point of its orbit. This remark applies with still greater force to Saturn, the revolution of which occupies 29 years. Hence, in this case, the Hindus were in error by 6 days.

If we pass to the ancient Greeks, we find a measurement of a terrestrial meridian, made about 200 B. C. by Eratosthenes, who found the circumference of the earth equal to 252,000 stadia. According to the researches of Tannery, the stadium as an astronomical unit equals 157.5 meters, which gives for the earth's circumference a length of 39,690 kilometers, instead of 40,000 kilometers, as we know it. Here the precision is remarkable, especially when we remember that this measurement was effected by counting the paces contained in an arc of the meridian, and by multiplying the number so found by the length of a pace.

One general remark must be made with regard to ancient astronomical observations. The observers have failed to inform us of their methods, merely recording the results without indicating the circumstances in which they were obtained, so that it is impossible to discuss their values and correct them with the aid of recent discoveries. The custom of recording methods along with results of observation, in order to permit subsequent discussion, is of quite recent growth. Methods are even omitted from issues of the Connaissance des Temps, published in the beginning of the nineteenth century.

The telescope was not invented until the commencement of the seventeenth century, all earlier observations being made with the naked eye. Now the eye can distinguish an object whose diameter is equal to about 1/3,000 of its distance, which corresponds to an angular diameter of about one minute of arc. This is the measure of the precision of early observations. It corresponds to the thickness of a lead pencil seen at a distance of 70 feet.

The instruments most frequently employed by early astronomers were divided circles and compasses with sights which allowed the line of vision to be directed to the star under observation. Ptolemy's ring was composed of two concentric vertical circles. The outer circle, about 16 inches in diameter, was fixed and graduated. It supported the interior ring, which was movable and carried the two sights. There was also a geometric square, which was used in a manner analogous to that of a table of logarithms.

We must now pass over a long succession of centuries of ignorance, during which human intelligence appeared to be asleep, before we arrive at the observations of Tycho Brahe (1546-1601). This astronomer, like his predecessors, employed wooden instruments. One of these was a large Ptolemy's ring surmounted by a post carrying horizontal arms, by which it was turned in bearings like a capstan, so that the ring could be brought into any vertical plane. Tycho Brahe also constructed a mural circle. Hence, it was by using the naked eye and rudimentary instruments that he accumulated observations of such precision, that they served Kepler as the basis of the researches which led him to the discovery of the planetary laws. By using Tycho Brahe's observations of Mars, Kepler discovered the variability of the earth's distance from the sun. He began by discussing twelve oppositions of Mars, observed by Tycho, during a period of 24 years. He considered the triangle formed by Mars, the earth, and the sun, and sought the epochs in which these three bodies again assumed such relative positions that the triangle formed by them was similar to the one first considered. The considerations of the similarity of these triangles led him to the conclusion that the sun is not in the center of the earth's orbit. The conception of the elliptical orbit did not, however, immediately occur to Kepler, who thought that the planets could not describe any other than the perfect curve, the circle. It was several years later that he thought of the ellipse, although its properties had long been known. We cannot regard Kepler's work without profound admiration. The methods of calculation at his disposal were very imperfect; for example, to calculate the position of a planet in the period between two observed positions, that is to say,

A CONVENIENT FORM OF AIR THERMOMETER.

to make an interpolation which a modern student can accomplish in a few minutes, required days of labor. Kepler's notebook, which is a sort of diary, contains many expressions of discouragement, but he always quickly resumed the work which was destined to conduct him finally to the discovery of the laws which have immortalized his name. In 1608, in Holland, was made the first combination of a convex and a concave lens. After this epoch, telescopes were gradually introduced into practical astronomy. In 1655 Huygens improved clocks by introducing the pendulum. The vernier made its appearance in 1631. In 1640 the optical axis of the telescope was practically defined, and the micrometer was introduced. Roemer improved the micrometer in 1672 by adding springs to suppress the lost motion. Roemer constructed the first meridian telescope in 1689. The precision of the observations of that epoch may be estimated at 10 seconds of arc, which corresponds to the diameter of a pencil seen at a distance of about 550 feet.

Methods and instruments continued to improve. The observations of Lalande attained a limit of precision of one second of arc, corresponding to the pencil at 5,500 feet. At the beginning of the nineteenth century great improvements were made. In 1875 the limit of precision had been reduced to one-half second, which removes our pencil to 11,000 feet, or more than 2 miles.

In order to obtain the maximum precision, the greatest possible symmetry in instruments must be maintained. In order to show what regard is now paid to symmetry, it will suffice to mention one of the precautions taken in the installation of the meridian telescope of the observatory of Toulouse. Each of the two pillars which support this telescope rests on a block of stone weighing four tons. These two stones are placed on a larger block weighing eight tons, which rests on a bed of concrete, which, in turn, rests upon a foundation of sand. In order to assure perfect similarity of the stones immediately under the pillars, Baillaud, then director of the observatory, had an eight-ton stone sawn in two under his personal supervision. Nevertheless, it was found that the western pillar sinks at the rate of 1/2,500 inch per year, owing to a gradual sinking of the hill on which the observatory is placed.

As the precision of observation increases, hitherto unsuspected causes of perturbation are discovered. An example occurred recently at the Observatory of Paris in an attempt to determine the vertical line, an operation which appears very simple. A telescope is directed vertically downward upon a horizontal mirror. If the cross-wire coincides with its reflected image, the axis of the telescope is vertical. The mirror, in this instance, was a bath of mercury. The result obtained was not satisfactory. After allowance had been made for all known errors arising from the instruments, the building and the daily heating and cooling of the pillars, there remained a periodic discrepancy of unknown origin. It was finally discovered that this discrepancy was due to the action of the moon, which produced appreciable tides in this basin of mercury a foot or so in depth. The most recent progress in the precision of observations is due to photography, but the dimensions of photographic plates are limited to about two or three times the apparent diameter of the sun. Ten thousand plates would be required for the map of the entire heavens. Joining plates together with the necessary precision is a very delicate operation, which requires the aid of the usual instruments for making direct measurements of stars. In mapping the heavens, a precision of 1/10 second of arc has been attained, which corresponds to our pencil at a distance of 10 or 11 miles. This is a result of which astronomers, those in France in particular, may justly feel proud.—Translated for SCIENTIFIC AMERICAN SUPPLEMENT from La Revue Generale des Sciences Pures et Appliquées.

A CONVENIENT FORM OF AIR THERMOMETER.

By E. EMMET REID, PH.D., Baylor University.

AS AIR has such a large coefficient of expansion, an air thermometer is particularly well adapted to show small changes in temperature. The large size of the column of liquid and the great distance it may be made to rise is a special advantage when a change of temperature is to be shown before a large number of people, as is frequently the case in scientific lectures.

The usual form of air thermometer is not convenient in several particulars. The air flask being at the top, it is impossible to insert it in a liquid. Owing to convection currents in the air, the usual form of air thermometer does not respond quickly to the heat of a burner, as the flame can reach only the top portion of it.

To overcome these difficulties, I have made one in this form, which may, or may not, be new. It was new to me and may be new to some other readers of the SCIENTIFIC AMERICAN.

AB is a glass tube of rather small size, 2 feet or more in length. This is bent over at the top. The lower end of this tube dips into colored water in a test tube. This test tube may be about 4 inches long. The test tube is fastened on to the long tube by a stopper, *D*, through which the long tube passes. Just below this stopper a small hole, *E*, is made in the test tube. This may be easily done by filing through the wall of the test tube. A layer of cord, *G*, is wrapped around the test tube and then the test tube is inserted in the neck of a flask, *E*, of suitable size. The double joint is made airtight by adding a layer of sealing wax, *H*.

A large test tube may be used instead of the flask. This form is useful for some purposes where the flask is too large.

An air thermometer made in this way may be readily used in almost any of the ways in which a mercury thermometer can be. A scale may be added if desired. When not in use it may be suspended from a nail by a loop of wire around the top of the tube.

The Cape to Cairo Railway, which recently reached a point 375 miles north of Victoria Falls, will, it is stated, be continued into the Congo copper district this season.

ELECTROLYTIC REFINING.

AN APPARATUS FOR THE TREATMENT OF METALS.

BY H. LACROIX.

IN precious-metal refineries the chief endeavor has been in the past to improve the chemical and electrochemical features of the refining process, to select the best conditions of density, composition of electrolyte, temperature, acidity, etc. The mechanical side of the problem has been rather seriously neglected, so that highly perfected processes are being carried out in rather rudimentary apparatus.

The tanks employed in gold and silver refineries are almost always simple rectangular boxes, generally of wood.

In the Moebius process of silver refining the electrolysis is carried out in tanks of this kind and the anodes are contained in canvas bags. The anode slime accumulates within these bags. When the anodes are consumed, the operation is interrupted and the bags are emptied. The cleaning of these bags is a long and delicate operation, which may easily involve serious losses.

The Wohlwill process of gold refining, which has been thoroughly studied from the electrochemical standpoint, is also carried out in simple tanks without diaphragm between the electrodes. On this account it is necessary to use as a starting anode material an alloy containing very little silver and to employ only a slight circulation of the electrolyte, as otherwise silver chloride might be mechanically carried over onto the cathodes.

Circulation of the electrolyte is almost always employed, but the methods are generally crude, circulation being obtained by stirring or other simple means. In some cases the electrolyte is introduced into the tank at one end and flows off at the other end, but attention is hardly paid to the exact path of the electrolyte through the tank.

Theory as well as practical experience prove, however, that it is advantageous to separate the anodic and cathodic portions of the electrolyte and to maintain the density of the electrolyte constant all over the surface* of the electrodes by continually bringing fresh electrolyte to the electrode surface.

These considerations have led the author to design the apparatus shown in two sections in Fig. 1. In practice it has given so far excellent results.

The anodic compartment comprises the space within the diaphragm cells *d*, the reservoir *r*, and the exit channel *m* which leads to the overflow *x*.

The cathodic compartment comprises the space outside of the diaphragms *d* and the reservoir *ka* with the walls *u s* and the inclined bottom *f*. There are holes in this inclined bottom, and through these holes pass the lower parts *p* of the diaphragm cells which are thus in communication with the lower reservoir *r*.

1 are the cathodes, 2 the anodes. The anodes 2 consist, of course, of the alloy to be refined and are suspended within the diaphragm cell. The electrolyte is in continuous circulation through the electrolyzing tank; it enters through the channel *n*, passes to the bottom of the cathode compartment, rises upward along the cathodes, passes over into the diaphragm cells through the holes *z* near the top, runs downward along the anodes into the space *r*, rises again through the channel *m* and leaves the electrolyzer through the overflow *x*.

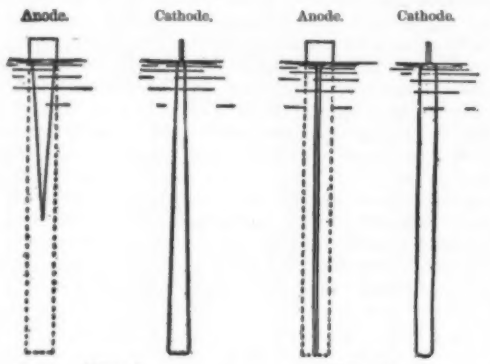


FIG. 2. FIG. 3.

CONSUMPTION OF ANODES AND DEPOSITION ON CATHODES WITH UNIFORM AND NON-UNIFORM DENSITY OF ELECTROLYTE.

During electrolysis the insoluble constituents of the anodes (the anode slime) fall down through *p*. The heaviest particles slide on the inclined bottom of *ka* and accumulate in *fa*. The lightest particles—those which tend to fall downward with less speed than the speed with which the electrolyte rises upward in the channel *m*—are taken along by the electrolyte to the outside of the cell and are there recovered by filtration.

Any particles of cathodic deposit which do not adhere to the cathode surface fall onto the inclined bottom *f* and accumulate in *fc*.

In this way the different constituents of the anode are automatically and continuously separated into the following parts:

(1) Adhering cathode deposit, i. e., pure refined metal.

(2) Non-adhering cathode deposit which accumulates in *fc*.

(3) Heavy anode slimes, accumulating in *fa*.

(4) Light anode slime, recovered on a filter outside of the tanks.

The flasks *fa* and *fc* are emptied as follows:

The globe valve *b*, which is normally raised above its seat or even completely removed from the apparatus, is first pushed down by means of the long hollow tube *ta* so as to close the aperture o_3. By any suitable means, preferably by a proper receiving flask (not shown in the illustration) the globe valve b_2 is then raised and flask *fa* is emptied while air enters through the hollow tube *ta*.

When *fa* is emptied, the globe valve b_2 is replaced so as to close the bottom hole and by means of *Ya* the flask *fa* is brought into communication with an outside reservoir containing electrolyte, its level being the same as in the electrolyzing tanks. The flask *fa* is thus filled with electrolyte while the air escapes through the long hollow tube *ta*. The cock *Ya* is then closed again and communication between *r* and *fa* is re-established by raising the valve b_2. This requires no effort, since the pressure is the same on both sides, nor does it cause any agitation nor any variation of the level of the electrolyte in the tanks.

It will be seen that the apparatus permits absolutely continuous operation, since the emptying of the flasks *fa* and *fc* and the renewal of anodes and cathodes does not require interruption of operation and may be done at any moment. For instance, it is unnecessary to wait with the removal of the anode slime until the anodes are completely consumed (which is, of course, unavoidable when the anodes are inclosed in canvas bags). This is quite an important point, since we have to do with slimes rich in gold and the interest item enters into the cost sheet.

This method of disposing of the slimes results in an operation with a minimum of loss. This is not unimportant, as an electrolyte of chloride of gold is employed, for instance, containing 30 grammes per liter. The hands of the attendants do not come in contact with the electrolyte nor with any part of the apparatus which is wetted by the electrolyte.

The forced circulation of the electrolyte along the electrodes permits to maintain an absolute uniform density all over the surface and consequently results in a perfectly uniform consumption of the anode and a perfectly uniform deposit on the cathode.

In ordinary tanks without circulation or with circulation by means of stirring, the anodes are consumed in such a way as to assume the form shown in Fig. 2, the bottom part being much more quickly consumed than the upper parts. The anodes, therefore, gradually assume a wedge shape. (The dotted lines represent the original shape, the drawn-out lines the shape later on.)

On the other hand, with the apparatus as described above, the consumption of the anodes is as shown in Fig. 3, the anode being corroded equally all over the surface so that at all times the two surfaces of the anode plate remain truly parallel. This enables one to use the full current to the last moment.

The rest, which is not consumed and which is returned to the foundry, is less than 8 per cent of the original anode weight.

This apparatus may be successfully employed for refining gold by the Wohlwill process, or silver by the Moebius process, or copper-silver-gold alloys by the Dietzel process.

As to gold refining, the Wohlwill process is well known and has been repeatedly discussed at length in this journal.

By the use of the apparatus described above, it is possible to treat the Wohlwill process gold alloys relatively rich in silver (containing up to 15 per cent silver), yielding gold of 100 per cent purity at the cathode.

The particles of silver chloride which detach themselves from the anodes or are scraped off, drop into the lower reservoir *r* and accumulate in the flask *fa*, from which they may be removed at will.

The electrolyte when enriched in gold in the diaphragm cells at the anode surfaces, leaves the tank through the overflow *x* and after filtration it is fed back to the tank into the cathode compartments and gives off gold to the cathodes. However this circulation may be carried out, it is impossible for silver chloride particles to be deposited on the cathode to-

* Electrochemical and Metallurgical Industry.

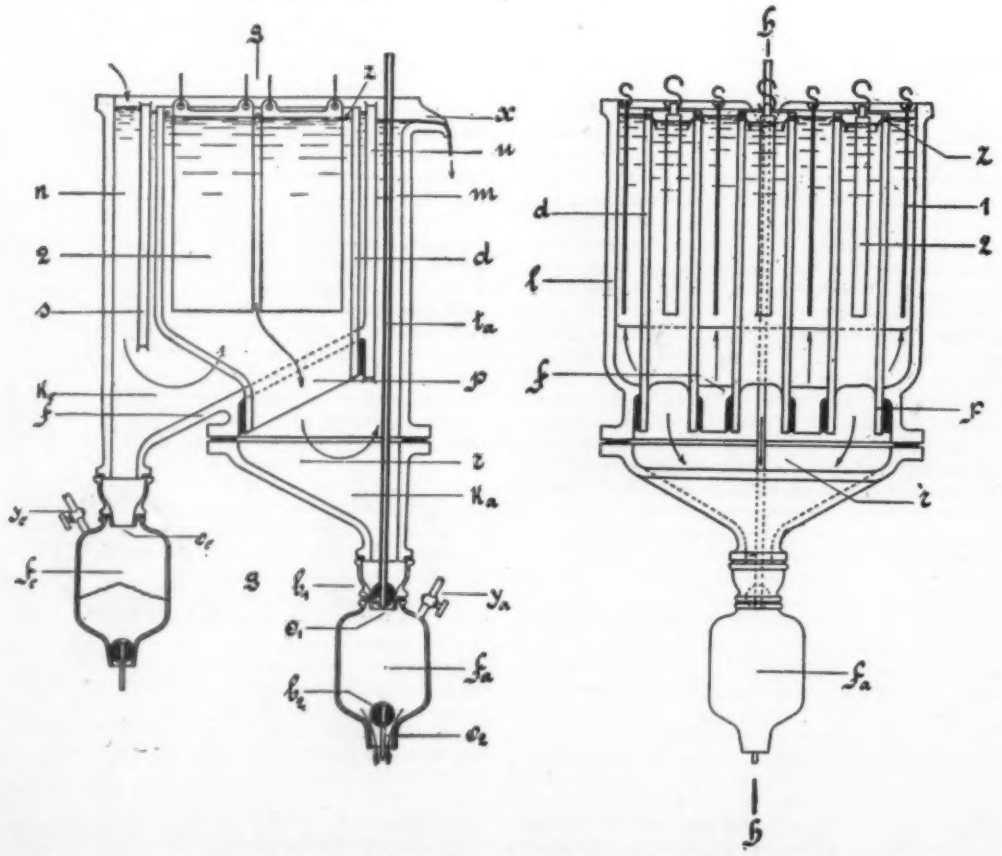


FIG. 1.—SECTIONS OF ELECTROLYTIC REFINING APPARATUS.

gether with the gold. It is further possible, even with a comparatively high proportion of silver in the anodes, to use a current density above 10 amperes per square decimeter, with sufficiently strong circulation.

In refining silver by the Moebius process the silver is deposited in form of crystals on the cathodes. When scraped off, the silver drops on the inclined bottom *f* and collects in the flask *fc*.

The insoluble anode slime, consisting principally of gold, falls into the reservoir *r* and accumulates in the flask *fa*. The electrolyte is returned after filtration to the cathodic compartment.

In the Dietzel process for refining copper-silver-gold alloys the cathodes are made of copper and the cathodic deposit consists of copper. Silver, copper, and some impurities pass from the anodes into the electrolyte, while gold and other insoluble constituents drop into the flask *fa*. The electrolyte running from the anode compartment of the tanks contains silver nitrate and copper nitrate. Outside of the tank the silver is almost completely precipitated on copper. The electrolyte is then passed into the cathode compartment of the tank where the copper is alone deposited.

The apparatus described above is particularly suitable for this process and permits the treatment of alloys of such variable composition as between 50 and 90 per cent silver and between 0 and 28 per cent gold, yielding silver of 99.9 per cent purity, gold of 100 per cent and copper of 99.8 per cent.

Serious difficulties had to be met in the construction and installation of this apparatus, but they have been successfully overcome and various electrolyzers of this type, which are patented in all the principal countries, have been in regular operation for about two years.

USINE DE DÉGROSSISSAGE D'OR.
Geneva, Switzerland.

THE PROBLEM OF TELE-VISION.

A PARTIAL SOLUTION.

BY DR. MAX DIECKMANN.

THE transmission of a photograph by Korn's method occupies from 5 to 10 minutes. As the persistence of retinal images is limited to about 1/10 second it would be necessary to multiply the rapidity of the process by 3,000 in order to obtain vision at a distance by this method.

In order to transmit in 1/10 second a picture measuring 3½ by 5 inches, which in transmission is drawn out into a strip 1/75 inch wide and more than 100 feet long, it would be necessary to send nearly one million electrical impulses per second from the transmitting to the receiving station. Such a speed of transmission

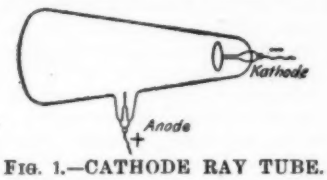


FIG. 1.—CATHODE RAY TUBE.

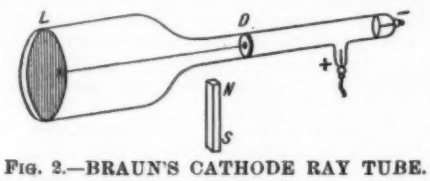


FIG. 2.—BRAUN'S CATHODE RAY TUBE.

is far beyond the capability of the conductor, as well as that of the receiver of the present apparatus. The frequency of the impulses that can be transmitted through a long conductor is limited by the electrostatic capacity of the wire, and every receiver yet invented, even Korn's very light relay, possesses far too much inertia to respond to the demands of vision at a distance.

Hence it appears proper to recall the attention of the inventors who are working on this problem to a well-known physical phenomenon, the cathode ray, and to certain experiments made by Dr. Glage and the writer two years ago.

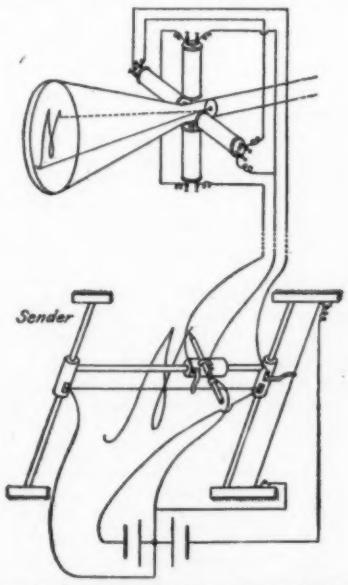


FIG. 3.—APPARATUS FOR TRANSMITTING PICTURES WITH CATHODE RAY RECEIVER.

Cathode rays were discovered by Hittorf in 1869. As the air is gradually removed from a glass vessel (Fig. 1) containing electrodes connected with the poles of an influence machine or an induction coil, the colored glow, which at low degrees of rarefaction fills the entire space between the electrodes, recedes from the cathode, leaving a dark space which becomes longer as the rarefaction increases, until it fills the vessel. The glass wall of the vessel, opposite the cathode, then begins to glow with a yellowish green light. This glow is due to fluorescence excited in the glass by invisible rays, the cathode rays, which the cathode emits at right angles to its surface. A screen interposed in the path of these rays casts a distinct shadow on the fluorescent glass. The cathode rays cause various salts and minerals to fluoresce even more brightly than glass. According to recent theories the cathode rays are streams of electrons, or particles of negative electricity, each electron being equivalent to a change of 3.4×10^{-10} electrostatic units of negative electricity. Under the influence of an electromotive force of many thousand volts the electrons move with from 1/10 to 8/10 of the velocity of light, and they move in straight lines unless they are deflected by some extraneous force. Wehnelt has shown that slower cathode rays can be produced with a comparatively small electromotive force, if the cathode is coated with certain oxides and is kept hot. The cathode rays are strongly deflected by magnetic and electrostatic forces.

FIG. 4.—WRITING TRANSMITTED BY APPARATUS OF FIG. 3.

In studying these effects Braun employed a long and highly exhausted tube with an enlarged portion at one end (Fig. 2) and the cathode at the other, while the anode was fused into a branch tube not far from the cathode. A perforated diaphragm at *D* allowed only a narrow pencil of cathode rays to enter the wide part of the tube and strike the opposite end of it, *L*, consisting of a plate of mica coated with a fluorescent substance, where the point of incidence of the pencil was revealed by a blue-green luminous spot.

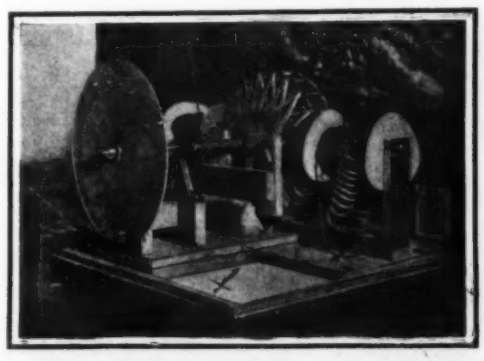


FIG. 5.—DYNAMO OF RECEIVING STATION FOR VISION AT A DISTANCE.

As the pencil of cathode rays is composed of swiftly moving particles of electricity it is deflected by a magnet as a movable conductor bearing an electric current would be deflected. In the case represented in Fig. 2, the pencil is deflected toward the right by the north pole of the magnet *N S* placed vertically under the tube.

Now the important point is that the cathode rays obey the deflecting force instantaneously in consequence of their infinitesimal inertia. For this reason Braun employed cathode rays in investigating the curves of variation of rapidly alternating currents,

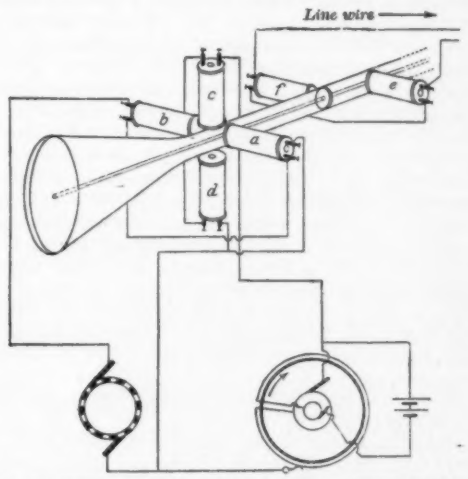


FIG. 6.—RECEIVING STATION FOR VISION AT A DISTANCE.

which he caused to act on the rays by means of electromagnetic coils traversed by those currents. Although other investigators also obtained valuable results with the Braun tube, the apparatus has not been properly appreciated and developed by inventors.

Fig. 3 illustrates the method by which we directly transmitted and reproduced writing and drawings by means of the Braun tube and three live wires. The tracing point at the transmitting station (Fig. 3, below) was attached to a sliding piece, the guide bar of which was borne by two pieces sliding on bars perpendicular to the first bar. Every movement of the tracing point was thus mechanically resolved into two mutually perpendicular components. The movements of the sliders, by causing variations in resistance, produced corresponding fluctuations in two currents which passed through the live wires to the receiving station. The receiver (Fig. 3, above) was a Braun tube surrounded by two vertical and two horizontal electromagnets. One of the currents from the transmitting station traversed the vertical coils and its fluctuations caused horizontal displacements of the cathode rays and the fluorescent spot produced by them. The other current energized the horizontal coils and moved the spot vertically. The combination of these horizontal and vertical movements caused the luminous spot to trace an exact copy of the design followed by the point at the transmitting station. In this way we found no difficulty in transmitting drawings and written words in a few seconds (Fig. 4).

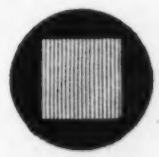


FIG. 7.—SQUARE OF LUMINOUS PARALLEL LINES.

FIG. 8.—COPY OF PATTERN PROJECTED ON LUMINOUS SQUARE.

Many instances of transmitting and receiving apparatus capable of accomplishing similar results have

been invented, but the following experiment has probably not been performed by any other method.

We constructed a small dynamo (Fig. 5) which furnished current to the four deflecting magnets *a*, *b*, *c*, *d* of the receiver (Fig. 6). The machine was designed and operated in such a manner that the spot of light traced a succession of parallel and equidistant lines, with which it filled a small square (Fig. 7) in exactly 1/10 second, and then recommenced the process. In consequence of the closeness of the lines and the persistence of images on the retina, an eye placed opposite the large end of the Braun tube saw a rectangular luminous patch about 1¼ inches square. Behind the four coils and the diaphragm were two horizontal coils *e*, *f*, the function of which will appear.

At the transmitting station a fine metal brush moved synchronously with the luminous spot at the receiving station, covering an area 1¼ inches square with invisible lines in exactly 1/10 second. A sheet metal pattern was applied to this area. When the moving brush touched the metal an electric current was sent through the live wire to the receiving station and through the coils *e*, *f*. The magnetic field thus produced deflected the cathode rays vertically to such an extent that none passed through the hole in the diaphragm. During the passage of the brush over the pattern, therefore, no rays reached the fluorescent screen and no luminous spot was formed. The result was the obliteration of those parts of the luminous square which correspond to the area of the metal pattern or, in other words, the production of an exact copy of the pattern in black on a luminous field (Fig. 8). As the entire copy was produced in 1/10 second it followed every movement impressed on the pattern.

This experiment shows that the cathode ray is well worth the attention of inventors in search of apparatus destitute of inertia. But the retarding effect of the electrostatic capacity of a long conductor cannot be overcome by the employment of cathode ray tubes as receivers. Hence wireless telegraphy appears to offer the best promise of a solution of the problem of vision at a distance. The writer is now engaged in experiments in this field.—Adapted for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

THE VOYAGE OF "ZEPPELIN II."

THE OFFICIAL REPORT.

IN the Berlin Imperial Gazette of the 21st instant Count Zeppelin gives a very lucid account of his famous 38 hours' voyage in "Zeppelin II," which resulted in semi-disaster, attributed to the careless steering of the helmsman. Count Zeppelin commences by stating that his object was to prove that the new airship, constructed with funds supplied by public subscription to replace its predecessor, which was destroyed at Echterdingen, possessed all the qualities which he attributed to it. The crew, he says, consisted of eight men, and gasoline and oil sufficient to keep the two motors working for thirty-four hours was taken on board. He selected the direction of Berlin in order to show that he was in a position to travel that distance at any time, and also because in the event of his having to land he could reckon on the assistance of the Balloon Battalion. He kept his project secret so that in the case of failure it might not seem that the enterprise was unsuccessful, and also in order to avoid disappointing the people who might be awaiting his arrival. Rain was falling when he made his preliminary ascent on May 28th, and he maneuvered over Lake Constance for three-quarters of an hour, where it fell heaviest, to ascertain the effect on the gasholder. The water ultimately penetrated the covering and fell into the cars and increased the weight to such an extent that ballast had to be thrown out.

When he started for his long trip on the evening of May 29th rain was again falling, and unfortunately the astronomical instruments required for the journey had not arrived. The loss of weight resulting from the use of gasoline in the motors and the effect of the sun's rays on the gas made it desirable to obtain a fresh supply of water ballast by letting buckets down into the Deutzendteich, near Nuremberg, but so many boats were on the water that this could not be accomplished. Between Leipzig and Bitterfeld it was considered advisable to return in order to obviate the necessity for landing for a fresh supply of gasoline. Berlin could not in any case have been reached until late at night. After telegrams had been dropped at Bitterfeld and the return voyage commenced, darkness prevented Count Zeppelin from ascertaining his position, and with one motor working he traveled slowly in wide circles for five hours.

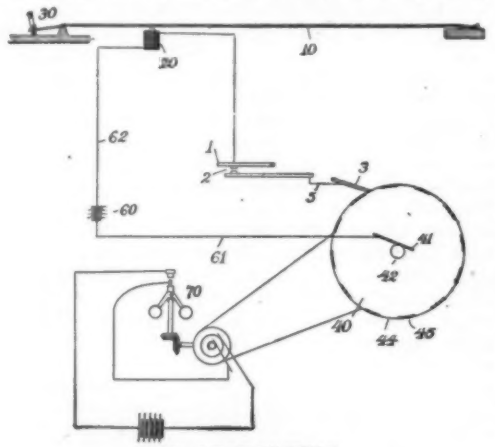
At daybreak he discovered that the airship was over Schweinfurt, and a course over Würzburg, Heilbronn, Stuttgart, Ulm, and Friedrichshafen was decided upon. He chose this route because he knew of several places on the way where, if necessary, he could land to obtain fresh supplies of gasoline and oil. It seemed probable that home could be reached with both motors working, but on the other side of Stuttgart such a strong head wind was encountered that it was decided to renew the stock of gasoline and oil at Göppingen. In attempting to reach a very favorable landing place on a flat piece of ground the steersman, who was attempting to describe a large curve, allowed the airship to be driven into a valley, and, instead of turning round and leaving the valley where he entered it, he directed the airship over a hill. Owing to the circumstance that the airship was traveling against the wind it could not be raised sufficiently high quickly enough, and being, moreover, caught over the hillside in a downward current of air it could not be prevented from running into a tree. The rigid framework of the balloon saved the crew and the machinery from the effects of the collision, but it was bent as far as the first car, the cover was torn off, and the front gas cells were destroyed.

When the mishap occurred the balloon had been in the air for thirty-nine hours and had not lost a cubic meter of gas or a liter of water ballast; so that if gasoline and oil had been obtained at Göppingen the "Zeppelin II" would have been ready to start afresh on an equally long voyage. The airship was provisionally repaired, but, owing to the fact that several gas cells were wanting, its carrying power was reduced. The front motor was therefore removed, and the engineer, Herr Duerr, who now assumed command, could take only four men with him.

Against a head wind, which at times was rather strong, with a blunt bow and with only one motor, the airship proceeded slowly. It was permitted to rise as the sun's rays affected it. When it reached the height of 4,000 feet much gas was lost, and a second landing became imperative at half-past eight, when the air became considerably cooler. Everything of weight that could possibly be dispensed with was thrown out, and fresh gasoline and oil for the motors having been obtained from motor cars the voyage to Friedrichshafen was completed without a new supply of gas.—Flight.

THE "CHORALCELO." A NEW MUSICAL INSTRUMENT.

A MUSICAL instrument known as the "choralcelo" was recently exhibited in Boston which produces musical notes not by mechanical means, such as striking a tense string with a hammer or drawing a bow across the string, but by electrical means, the string being



THE CHORALCELO.

set in vibration magnetically. The inventors are Melvin L. Severy and George B. Sinclair.

When a piano string is brought into the field of an electromagnet having a definitely timed number of electric pulsations conveyed thereto, and the string is gradually tuned up to vibrate in accord with the pulsations, the instant they are in exact accord the string will respond with a markedly pronounced maximum loudness, while if tuned but slightly sharp or flat, the resonance will at once fall off and become much weaker. Furthermore, as the string departs in the slightest degree from the number of vibrations per unit of time given by the electromagnet, not only does its volume decrease, but the quality of the tone changes as well. Hence, by providing a standard set of electromagnets and pulsating devices for the piano strings, and then gradually tightening each wire until its magnet fails to increase its loudness of vibrations further, the operator can know that the spring is in exact tune. Or if he tightens the wire a trifle too much, as evidenced by its diminution in loudness, he loosens up thereon until again the maximum volume is reached. When the operator becomes more experienced, he can also detect the exact point by noting the change in quality of sound produced.

In carrying the invention into effect for merely tuning ordinary pianos all that is needed in the way of apparatus is a single electromagnet, and a device for imparting thereto any desired number of standard pulsations. This magnet being supported in close proximity to any one of the strings, and the electric pulsations appropriate to the string communicated to the magnet, all that the tuner needs to do is to tighten up or loosen the wire until its maximum loudness and proper quality are reached. Then the magnet can be shifted to the next string; the pulsations changed in accordance therewith, and the tuning done as before. The process is, however, especially designed for electric pianos wherein the strings are vibrated by electromagnets permanently in place. Hitherto the method of tuning the strings was that of the old-time piano tuner—to turn the tuning-hammer and strike the note until the latter reached the standard set by the tuning fork; striving to reach the point where the beats, which showed a near approximation, should wholly cease. As different tuners' ears vary in their capacity to detect the exact vanishing point of these beats, it is impossible to tune all pianos precisely alike, even with the same standard. This, however, is a comparatively insignificant matter in comparison with the inability of even the same tuner to get identical temperaments on two or more pianos, or to duplicate the temperament in the same instrument when it is retuned; for the reason that the question of temperament is one of individual judgment, of compromise with exact chords.

Formerly the only known method of tuning electrically actuated pianos was first to change the tension upon each string until it suited the tuner's ear, and then to time the pulsation-producing mechanism until it accorded with the vibrations of the strings. In other words, the pulsation-producing device of each string is planned to deliver the proper number of impulses per unit of time to equal the theoretical number of its strings' vibrations. Then the strings are tuned in the usual manner, and the pulsation-producing motor speeded up or down until the periodicities thereof approximate the strings' vibrations. This is never satisfactory, however, inasmuch as no man can accurately temper the scale of the piano twice alike, and much less can two professional tuners make two different instruments with their scales exactly the same, so that the strings are never brought to the precise pitch for which their pulsation-producing mechanism is planned. This renders the piano irregular and uneven in tone and unreliable and uncertain in timbre. By means of the new process, however, the inventors are enabled to produce an instrument wherein not only are the strings tuned into exact accord with the standard established for every note in the entire scale, but wherein the strings vibrate with a maximum volume with a minimum expenditure of current, and which can be kept in perfect tune by any person who will follow the simple directions laid down.

Referring to the drawings, which show a means for carrying the process into effect, the reference numeral 10 designates a piano string having a tuning pin 30, and an electromagnet 20 in close proximity thereto. The rotating disk 40 having its periphery divided into alternate sections of conducting and non-conducting material 44, 45, acts in connection with the brush 3, wire 5, source of electricity 60, lead-wires 61, 62, and brush 41, to impart to said magnet the desired electric pulsations. 1 and 2 represent a key and contact by which the pulsations are turned off and on to the magnet. By turning the pin 30, the string is tightened or loosened in the usual manner. In tuning said string, the electric pulsations produced by the current-breaker 40 and exactly timed by a governing device 70, are continuously maintained in the electromagnet 20 while the string is being tightened. As the string approaches an octave below the set standard, it will increase in loudness, and then diminish as the tuning is continued past, but the quality of the note produced will make it evident that the string has not reached the true pitch for which it is designed. So the tight-

ening is continued until a second marked increase in loudness and a richness of quality in the note produced prove that the string has reached the set pitch. Should the tuning-pin turn slightly too much, the diminution in loudness and quality shows instantly that the true point has been passed.

By providing an electromagnet vibrating device for each string and by providing a keyboard, which is in reality a switchboard, upon which a musician may play, the choralcelo is created—an instrument which produces music without striking the strings of the instrument.

THERMODYNAMICS IN THEORY AND PRACTICE.

GAS ENGINE TESTING SUGGESTIONS.

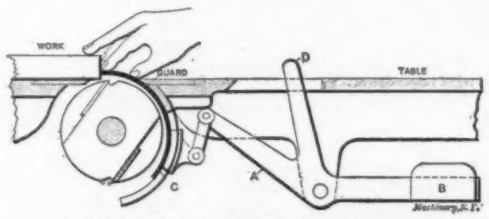
IT was the late Lord Kelvin, we believe, who likened the relationship between theory and practice to the operation of plotting a curve. Practice, he said, was the series of points, and theory the curve which joined them. No better simile than this could be found, for besides expressing the relationship between theory and practice, it also implies the order of precedence. One must have the series of points before one can proceed to draw the curve, and because the one must take precedence of the other there are some—a fast-diminishing number—of the so-called "practical" school who consider that acquaintance with theory is to be despised. The value of theory is—to pursue the metaphor—in enabling one to interpolate, and in some cases exterpolate, so that after a sufficient number of observations have been made and a law established it is possible to predict results under different conditions from those already experienced. It is a matter of common experience in plotting results to find some of the points apparently a long way off the fair curve, and where the apparent discrepancy cannot be assigned to errors of observation it is clear that there has been a variation of the condition under which the observations have been made. In such cases the theory is incomplete, and its application must be attended with a more or less degree of uncertainty. A standing example of our inability to combine all the practical conditions in a complete theory is to be found in the screw propeller, with the result that the researches and experiments of half a century are of small value when we pass from the reciprocating engine to the turbine with its higher speed of revolution. The science of thermodynamics is another glaring example of the unreliability and uncertainty of the practical application where the theory is incomplete.

Now we are quite aware that there is a thermodynamics the theory of which is complete, but unfortunately it deals with a substance called a perfect gas, which does not exist. The theory begins with a definition of an absolute scale of temperature. There is no bar to practical application in this, as it is only a convention for representing the state of molecular activity of the substance, but when we go on to connect the temperature with the pressure and volume of the substance our knowledge is not perfect except within a limited range. Boyle's law we know is sufficiently exact within ordinary temperatures, but what we do not know is whether the law changes entirely at extreme temperatures or whether the law is some very complex one which does not change at all, but which by a coincidence approximates to the very simple form of Boyle at ordinary temperatures. Seeing that the theory is so incomplete in its foundations, it is not surprising that little reliance is to be placed upon the superstructure. On the other hand, the view that the study of the theory of thermodynamics is only useful as mental gymnastics or as serving as a peg on which to hang examples in the calculus is surely the other extreme. The practical problems confronting the engineer in the turning of heat into work—and we write now more especially with reference to the internal combustion engine—are very complex, and it is necessary to consider the simple cases, even though they involve assumptions which are not strictly true, before one can hope to approach the more intricate propositions. One has also to consider that even if it were possible to construct a complete theory taking account of all possible factors, the resulting algebraic expressions or equations would in all probability be much too cumbersome for practical use; and, in any case, the constants for use with the formulæ or equations would have to be determined by experiment. What one has to do, then, is to take the simple theory so far as it goes and proceed the rest of the way by empirical or semi-empirical methods. No better example can be found of the value of simple theory than the calculation of the efficiency of the gas engine in terms of the compression. As is well known, if we assume the working fluid to have the properties of a perfect gas with constant ratio of the specific heats at constant volume and constant pressure, then when the heat is added and rejected at constant volume the efficieney depends upon the compression alone. This efficiency is called the absolute efficiency, or, recently, as air is always supposed the working fluid, the air standard efficiency. Now, apart from the facts that the working fluid is not entirely made up of air, that the ratio of specific heats is in all probability not constant, and that it is by no means certain that in any one case is all the heat added at constant volume, there is the certain knowledge, which a little practical experience will soon give, that there are many factors which will influence efficiency besides compression. In spite, however, of these qualifications we do know that compression is still the main determining factor of efficiency, and the absolute efficiency can be used with a good deal of certainty in predicting the actual efficiency of a given engine. The ratio of the actual to the absolute efficiency is now called the relative efficiency, and does not vary very much in a given type of engine. The value to the practical man of the simple theory is just this, he can calculate from the compression the absolute efficiency, and he knows from practical experience what proportion of this he may expect to realize. If he does not realize it there are points in the working of the engine which require to be looked into.

It will be said that most of the ills to which the gas engine is heir require no theory to help one to look for them, but while it is quite true that such defects as pre-ignition and back firing immediately *sautent aux yeux*, there are often cases, more especially among oil engines, where the consumption is above normal, while the engine appears to be working fairly satisfactorily. The practical man will be the first to admit that such a state of affairs denotes some defect which is not likely to improve, but rather to get worse, and sooner or later cause trouble. It is not, however, in such cases that the simple theory is of most value, but rather as a check against efficiency when the compression is altered. As to the variation in the specific heat, about which so much has been written during the last few years, it is not very apparent what use a more complete knowledge on the point will be to the designer, except that Mr. Dugald Clerk has shown that if, as is now generally supposed, the specific heat increases with the temperature, there is less margin for improvement in results with a given compression. In other words, we cannot expect to improve the relative efficiency much beyond the figure at which it stands at present in well-designed engines, i. e., about 65 per cent. What goes on in the cylinder during the very short interval between the passing of the spark and the attainment of the maximum pressure is still a closed chapter to us, and is likely to remain so until we know more of the laws which gases obey at the higher temperatures. So far as theory can throw any light at present, it might be assumed that with the same mixture and compression pressure, the more prompt the ignition (and, therefore, the higher the initial pressure) the better the efficiency.

The last report of the Gas Engine Research Committee, however, does not bear this out, and it is a common experience that the best results are often obtained with the top of the indicator card slightly rounded. If, however, the top of the card be too much flattened and combustion is proceeding for an appreciable distance along the expansion stroke, a falling off in efficiency begins to be noticed. The inference may be either that the heat at the highest pressures is not so usefully employed or that the pressures themselves introduce mechanical losses which more than compensate for the gain, and, reasoning on these lines, we have a probable explanation why it was found that an increase of compression above a certain limit resulted in a falling off in efficiency. The mystery surrounding the period of combustion is greater in the oil engine than in the gas engine, for in the former, whether we are dealing with oil which is vaporized externally to the cylinder or injected into it, we have a fuel which, in its gaseous state, is of uncertain composition. The compounds of carbon and hydrogen are legion, and under the influence of heat they "crack" and pass from one form to another with delightful irresponsibility. Each has its own boiling and ignition points, and each requires its own particular proportion of air for complete combustion. No theory can grapple with such obscure and uncertain factors, and practically the only application of first principles which can be made is that the greater the internal energy of the charge at the moment of ignition—that is, the higher the compression pressure—the more rapid and complete will be the combustion. In engines with combustion at constant volume the fiery nature of the more easily ignited constituents of the oil puts a limit to the compression, although it may be carried higher with water injection than without. Into the merits of this expedient we do not enter, but it is noteworthy that no satisfactory explanation has yet been made of the thermodynamic action of the water addition to the charge.

These and many other points require further light thrown upon them, and though much excellent work has been done already by firms and individuals, there is still a vast region of undiscovered country ahead. Meanwhile, it may safely be predicted that the best results will be obtained by those who have a sound knowledge of the theory of the subject so far as it goes, and who can apply that knowledge with discretion.—The Engineer.



A SWEDISH SAFETY DEVICE FOR BUZZ-PLANERS.

SAFETY DEVICE FOR BUZZ-PLANERS.

AN interesting and effective safety device for buzz-planers has been patented by Mr. Lundberg, of Wernamo Mekaniska Verkstad, Wernamo, Sweden. The general arrangement of this device is illustrated in the accompanying line engraving. The principle of the device is that plates or guards *C*, of a semi-circular form, are held up against the end of the work when it passes over the cutter, by a weight *B* on the end of lever *A*, suitable linkage connections being provided between the lever and the guard. A number of these guard plates are placed side by side across the full width of the planer. It will be noticed that one arm *D* of lever *A* extends up through the table of the machine when the guard is in action, but when the work entirely covers the opening over the cutter, having pushed the guard clear back, this end of the lever is turned below the surface of the table. The handle of the lever serves the purpose of hand adjustment of the guards. It will be noticed that the cutter is covered at all times, either by the work, the work and guard in combination, or by the guard alone, so that at no time is any part of the cutter exposed. The weight *B* on the end of the lever makes the action automatic.

This guard fills also some of the most important requirements of safety devices for machines of any type. In the first place, it is unobstructive to the working of the machine, and for that reason there is no incentive for the workman to remove it. Not only is there no incentive for the workman to remove it, but it is also very difficult to remove, and practically impossible to keep inoperative while in place. As the guard is made in sections, each of which covers a part of the full width of the table, it covers the cutter not only in line with the work, but completely on each side of the work as well. The simplicity of this construction, the ease with which it can be temporarily withdrawn for the changing of cutters, and the way in which it prevents dust and chips from entering into and obstructing the working of its own mechanism, are all factors which indicate the thoroughness of design, and that all the requirements have been well taken care of.—Machinery.

Enameling Pewter Articles.—For this purpose the surface to be decorated with enamel must have a somewhat deeply recessed ground. Corresponding to this, the enamel decoration is carried out on a metal that is difficult to melt. The enameled plate is then attached to the prepared surface of the pewter article and secured by soldering. The fastening may also be effected by turning the pewter edge over, so that the overlapping edge securely holds the enamel plate to the pewter.

SCIENCE NOTES.

When a man had more teeth than his jaw could conveniently hold, it used to be the theory of dentists to explain that he had inherited the large teeth of one parent and the small jaw of the other. Recently some good observers, notably Dr. Sim Wallace and Dr. Harry Campbell, of England, stated that the trouble is not hereditary; that it had its beginning in each person's babyhood, and that our teeth are poor and irregular and our jaws contracted because we do not exercise these parts sufficiently during the weaning process. In support of this statement, they point out the fact that the first set of teeth is practically never irregular, never overlaps, and is very seldom defective.

Some years ago several applications of the Thorp plane replica diffraction gratings were exhibited, notably their use with an opera glass for eclipse work. The only disadvantage of these is the necessity of employing glass lenses for collimator and telescope, which not only increase the expense, but render the instrument somewhat limited, in that the ultra-violet region of the spectrum is more or less absorbed. Recent experiments by Mr. C. P. Butler have shown that concave replica gratings can be made to give very satisfactory results; and by slight modifications of the design of mounting, this form of spectroscope may be employed for any investigation for which the ordinary spectroscope is fitted. A valuable feature appears to be that the radius of curvature may be varied within very wide limits, thus providing instruments of different dispersion and light-grasping power.

The old method of determining the temperature of a coal pile by driving pipes and hanging thermometers in them has been greatly improved by means of a special coal auger, similar in form to that used in the mines, but provided with a means of inserting a small maximum thermometer near the point. Extensions four feet in length (for convenience in carrying) may be attached to the auger, so that the thermometer can be readily inserted into any depth in a pile. The point of the auger can be driven 20 feet in three to five minutes. About ten minutes is required for the thermometer to attain the temperature of the surrounding coal. Temperatures taken in this manner are much more accurate than those obtained by hanging a thermometer down a pipe, where there is more or less circulation of air, making it impossible to locate the hottest spot. Temperatures obtained by means of the auger have been found to be 40 deg. Fahr. higher than by the pipe method.

In factories and other places where it is necessary to keep large quantities of quicklime, its preservation becomes an important problem, owing to the rapid deterioration of the substance in contact with the air. Lime becomes air-slaked even when fairly well sheltered. Furthermore, rooms in which quicklime is stored are very unhealthy, as the operations of storing and handling produce large quantities of lime dust, which is extremely injurious to the workmen. An attempt has been made to remedy these evils by the employment of silos similar to those used for wheat. These silos are placed in double rows in the storeroom and are hermetically closed. The lime is brought into the storeroom in covered wagons loaded with buckets, which are raised by a mechanical device, brought over the silo, and emptied by opening the bottom. Thus no dust is produced, and the lime is not exposed to air during transport. Each of these buckets contains 7 or 8 tons. The silo is emptied from below. One German installation includes a storeroom about 80 feet wide and 140 feet long, containing thirty silos with a total capacity of 1,800 tons. The buckets hold 8 tons, and the trucks which transport them have a capacity of 30 tons.

It has been said that a horse is about eight times as powerful as a man, and again it has been estimated that an athlete in a short sprint or in a football game develops for a short period energy at the rate of the so-called horse-power. When thus exerting himself to the utmost a man breathes rapidly and deeply, requiring large volumes of oxygen. On the other hand, while resting quietly or while asleep, the respiration is such that comparatively little oxygen is needed. Midway between these extremes is the moderately active person, moving about in the performance of ordinary duties. The above conditions have their effects on ventilation, for the extent to which the air is vitiated is directly proportional to the carbonic acid gas exhaled, which in turn is proportional to the air breathed. To determine the vitiation of air due to the presence of a man in a room with a gas jet burning, experiments were recently made by the Arthur D. Little, Inc., Laboratory of Engineering Chemistry, Boston, Mass., the results being shown in a curve interpreted to mean that the percentage of carbonic-acid gas exhaled varied with the activity of the man, the gas jet requiring a constant quantity of oxygen. During the first three hours the man moved about moderately, rested, and finally fell asleep. For the two hours (approximately) he was asleep, the vitiation was greatly reduced, but increased again when he awakened and moved about. The observations made during the tests proved also that an active man uses up the oxygen in air at about the same rate as does a gas jet burning five cubic feet of gas per hour, the capacity of the ordinary burner.

ENGINEERING NOTES.

The explosive range of marsh gas varies from 6 to 14½ per cent; the explosive range of carbon monoxide is much wider than this. The maximum explosive mixture of the above gas is one volume of CH to 9.5 volumes of air, and one volume CO to 2.4 volumes of air. Carbon monoxide gas is always found after the firing of shots. This gas has much greater power to elongate a flame than fire damp has, on account of its wider explosive range. Most of our miners can verify the statement, that they have on several occasions returned to the working face after firing a shot, applied their lighted lamps to the smoke, as it was issuing out from the coal, or between the coal and roof, from a shot that had failed to throw the coal, the result being a flame or small explosion.

In a paper recently read before the Iron and Steel Institute, Prof. H. C. H. Carpenter drew attention to the discrepancies in the readings by the three scales (the gas, the thermo-electric, and the optical scales) in use in the determination of high temperatures. The first is available to about 1,200 deg. C., and the thermo-electric agrees with this between 400 deg. and 1,200 deg. C. The optical scale, however, gives temperatures higher than those given in terms of the scale of the thermo-electric calculated by the formula which gives accord with the gas scale. The freezing point of iron calculated from several closely agreeing determinations by the thermo-electric method is 1,505 deg. C. on the thermo-electric scale, corresponding to 1,519 deg. C. on the optical scale; it is, moreover, independent of the atmosphere in contact with the iron, whether this be air, O, N, CO, CO_2, H, or mixtures of these.

A comprehensive table referring to large gas engines developing over 1,000 horse-power appeared in a recent issue of the Zeitschrift des Vereines deutscher Ingenieure. According to this table 628 gas engines of 1,000 horse-power and larger and representing a total amount of power equal to 1,035,700 horse-power have been built or are under construction at the present time. Of this total, 412 engines of 613,200 horse-power, or considerably more than one-half of the total, have been built in Germany; 154 engines with 337,500 horse-power in the United States; 33, with 42,200 horse-power in Belgium; 9, with 16,800 horse-power in France; 10, with 13,600 horse-power in Austria; and 11, with 12,400 horse-power in Great Britain. It is rather difficult to explain why the building of large gas engines has made so little progress in so highly developed a country as Great Britain, unless we ascribe this to the traditional conservatism of the Briton. The average size of the engines built in Germany was 1,500 horse-power; in the United States, 2,200; in Belgium, 1,300; in France, 1,900; in Austria, 1,400; and in Great Britain, 1,100 horse-power.

A new process for the commercial utilization of the solid residuum of sewage, the invention of Dr. Grossman, is being carried out in the north of England. The system is both hygienic and effectual, while the resultant product is distinctly valuable from the commercial point of view. The disposal of this solid matter is under existing conditions a somewhat difficult matter, the general practice in vogue being to consume it in dust destructors. In the Grossman process, however, the sludge is distilled, and therefrom are obtained large quantities of grease and dry odorless fertilizer in sufficient quantities and of a value to more than defray the cost of production. The process is simple. The sewage after being freed of its coarsest suspended matter is passed along to the settling tanks, where the solids in course of a few weeks sink to the bottom, forming a thick sediment. The superfluous liquid is then drawn off. As the solid matter is, however, still associated with about 90 per cent of water, it is subjected to pressure, which results in about 30 or 40 per cent of the loose water being eliminated. After pressure the sludge is thrown into a retort in conjunction with certain chemicals, where it is distilled at a certain temperature with superheated steam. The escaping steam carries off all the grease, which is afterward recovered in cooling towers, the grease being blown out into cool water, upon the surface of which it floats in thin white flakes, a fine dry black odorless powder, rich in nitrogen, remaining in the retort. The quantity of grease recovered from the residuum is about 5 per cent, and finds a ready market at about $35 per ton. The presence of such a high proportion of grease is due to the extensive amount of soap that is consumed, the greater part of which finds its way into the sewers. The yield of dry fertilizer from a ton of pressed sludge is from 7 to 8 hundredweight, and this finds an easy sale among the artificial manure manufacturers at an average price of $1.50 per ton. Where it combines with phosphates on the spot, after its withdrawal from the retorts, it could easily command a price of $6 per ton sold direct to the farmers. With a flow of 3,000,000 gallons of raw sewage per day, about 20 tons of pressed sewage is available. The inclusive cost of the process carried on continuously is about $1.25 per ton of pressed residuum; and as the net sale of the products realizes $1.83, a profit of 58 cents per ton of pressed sludge is thus available.

TRADE NOTES AND FORMULÆ.

Indelible Ink.—Two parts each of yellow prussiate of potash, ammonia, and tartaric acid are dissolved in 240 parts of water, the solution filtered and then 160 parts of ferro-citrate of ammonia, 40 parts of ammonia, 8 parts of aniline blue, 70 parts of gum, and finally, 20 parts of pyrogallic acid added.

Grease-proof Paper and Cardboard.—According to the Randolph patent, 11 parts of water glass, ¼ part mica, ⅝ part glycerine are thoroughly mixed in a suitable vessel, add ¼ part of brown sugar dissolved in hot water, ¼ part of rice flour washed in water, ¼ part of gum arabic dissolved in hot water to make a thin fluid, and ⅛ part prepared chalk. The mixture is applied by means of a soft brush to the paper or card and allowed to dry; the paper is then ready for use.

Cellulith.—According to an English patent, cellulose is ground finely in water, until no more fibers are visible. A portion of the water is then removed by filtration, pressing, or in any other manner, and the material transferred to molds. It is then dried in the air, or at a temperature of about 105 deg. F., at which it contracts, becomes hard and dense. Other substances may be added to the pulp, such as coloring matters, heavy-spar, lamp-black or salts, which can afterward be washed out, rubber or dissolved shellac, in order to produce a water-proof product. Cellulith is said to be adapted for use as a substitute for horn, wood or vegetable ivory.

Varnish for Wood That Will Withstand Boiling Water.—Boil in a strong copper kettle 750 parts of linseed oil and hang in a bag, that must not touch the bottom, containing 150 parts of litharge and 92 parts of pulverized red lead. The boiling of the oil is continued until it has assumed a dark brown color. The bag is then withdrawn and replaced with another, in which a clove of garlic is contained; this to be repeated several times with fresh cloves of garlic. Then place 500 parts of amber in a finely pulverized condition and 60 parts of linseed oil over the fire, allow it to melt and introduce it, while still boiling, into the boiled linseed oil, allowing the whole, stirring vigorously, to boil 2 to 3 minutes, then take it off, pour off what is clear, and after cooling pour it into closely-corked vessels for keeping.

Enamel Paper.—For this purpose, says a German writer, the glacé paper employed by lithographers is used. It has a shining white coating, the pigment of which consists of sulphate of baryta. This coating is very sensitive to fluids, softening at once in contact with them, which fault, where the paper is to be used for photographic purposes, into which fluids largely enter, must be removed. The paper is for this purpose floated on a mixture of 1 part of albumen and 1 part of water and then dried. Then we take a shallow iron vessel, fill it about 2 centimeters (¾ of an inch) deep with water and stretch over it first coarse linen and then flannel. On this the paper sheets are laid, one on the other, the whole is covered with flannel, and the water allowed to boil. After a few minutes the albumen is coagulated, the sheets of paper are taken off and redried. The coating is now completely impervious to water, acids, alkalies, alcohol, and ether. Finally, the paper, like albumen paper, is treated with salt and albumen and is then ready for use.

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